Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts

LUMINARY Memo #97

To: Distribution
From: D. Eyles
Date: 16 July 1969
Subject: Anomaly 79 Test Data

TRW's voluminous LNY 79 suggested that during the last minute of the landing approach phase (P64 TGO > -70) a lateral redesignation of $6^{o}$ or a landing radar, lateral velocity noise spike of 7.5 f/s will cause attitude oscillations in roll. See plots 1 and 2 of CDUZ from TRW runs.

This memo contains the results of similar runs made at MIT. These were the basis of MIT's response to LNY 79, delivered by George at the FSRR. No change in the deadband for the landing; and no change in the guidance equations was recommended for the program that would fly Apollo 11. Although in one run undamped behavior did result, this was late enough in P64 that P65 had to take over before rates exceeded one or two degrees per second - assuming that the landing is still at this point completely automatic, which itself is doubtful. The mechanism of the oscillatory behavior is deadband overshoot coupled with guidance sensitivity (due to a small TGO). Because there are site-visibility advantages and no fuel penalty in using a $.3^{o}$ deadband in P64 only, this change is being made for Luminary 1B.

The runs were made without terrain on LUMINARY revision 99 and LMY99 revision 1. Note that the perturbations actually entered at TGOs 2-4 seconds nearer zero than the nominal value, e.g. TGO -46 instead of TGO -50. The magnitude of the noise spikes upon incorporation into the state vector is 1.5 f/s, i.e. 7.5 f/s multiplied by the radar weighting factor in use at this time. This is the maximum spike the reasonability test will allow to be incorporated.

The rest of the memo is plots, for which an index immediately follows.

## TRW PLOTS

1. CDUZ and CDUZD, $6^{o}$ redesignation at TGO -70, deadband $1.0^{o}$
2. CDUZ and CDUZD, 7.5 f/s spike at TGO -50, deadband $1.0^{o}$

## MIT PLOTS

1. CDUX and CDUXD, $6^{o}$ redesignation at TGO -70, deadband $1.0^{o}$
2. CDUY and CDUYD, "
3. CDUZ and CDUZD, "
4. CDUX and CDUXD, $6^{o}$ redesignation at TGO -70, deadband $0.3^{o}$
5. CDUY and CDUYD, "
6. CDUZ and CDUZD, "
7. CDUX and CDUXD, 1.5 f/s spike at TGO -70, deadband $1.0^{o}$
8. CDUY and CDUYD, "
9. CDUZ and CDUZD, "
10. CDUX and CDUXD, 1.5 f/s spike at TGO -70, deadband $0.3^{o}$
11. CDUY and CDUYD, "
12. CDUZ and CDUZD, "
13. CDUX and CDUXD, 1.5 f/s spike at TGO -60, deadband $1.0^{o}$
14. CDUY and CDUYD, "
15. CDUZ and CDUZD, "
16. CDUX and CDUXD, 1.5 f/s spike at TGO -60, deadband $0.3^{o}$
17. CDUY and CDUYD, "
18. CDUZ and CDUZD, "
19. CDUX and CDUXD, 1.5 f/s spike at TGO -50, deadband $1.0^{o}$
20. CDUY and CDUYD, "
21. * CDUZ and CDUZD, "
22. CDUX and CDUXD, 1.5 f/s spike at TGO -50, deadband $0.3^{o}$
23. CDUY and CDUYD, "
24. CDUZ and CDUZD, "

* This is the plot that shows undamped behavior.

25. CDUX and CDUXD, 1.5 f/s spike at TGO -40, deadband 1.0°
26. CDUY and CDUYD, "
27. CDUZ and CDUZD, "
28. CDUX and CDUXD, 1.5 f/s spike at TGO -40, deadband 0.3°
29. CDUY and CDUYD, "
30. CDUZ and CDUZD, "
31. CDUX and CDUXD, 1.5 f/s spike at TGO -50, deadband 1.0°, LEADTIME 3 secs
32. CDUY and CDUYD, "
33. CDUZ and CDUZD, "
34. CDUX and CDUXD, 1.5 f/s spike at TGO -50, deadband 1.0°, LEADTIME 3.5 se
35. CDUY and CDUYD, "
36. CDUZ and CDUZD, "

Figure 6

REDESIGNATION CASE 1 - MIDDLE GIMBAL ANGLES

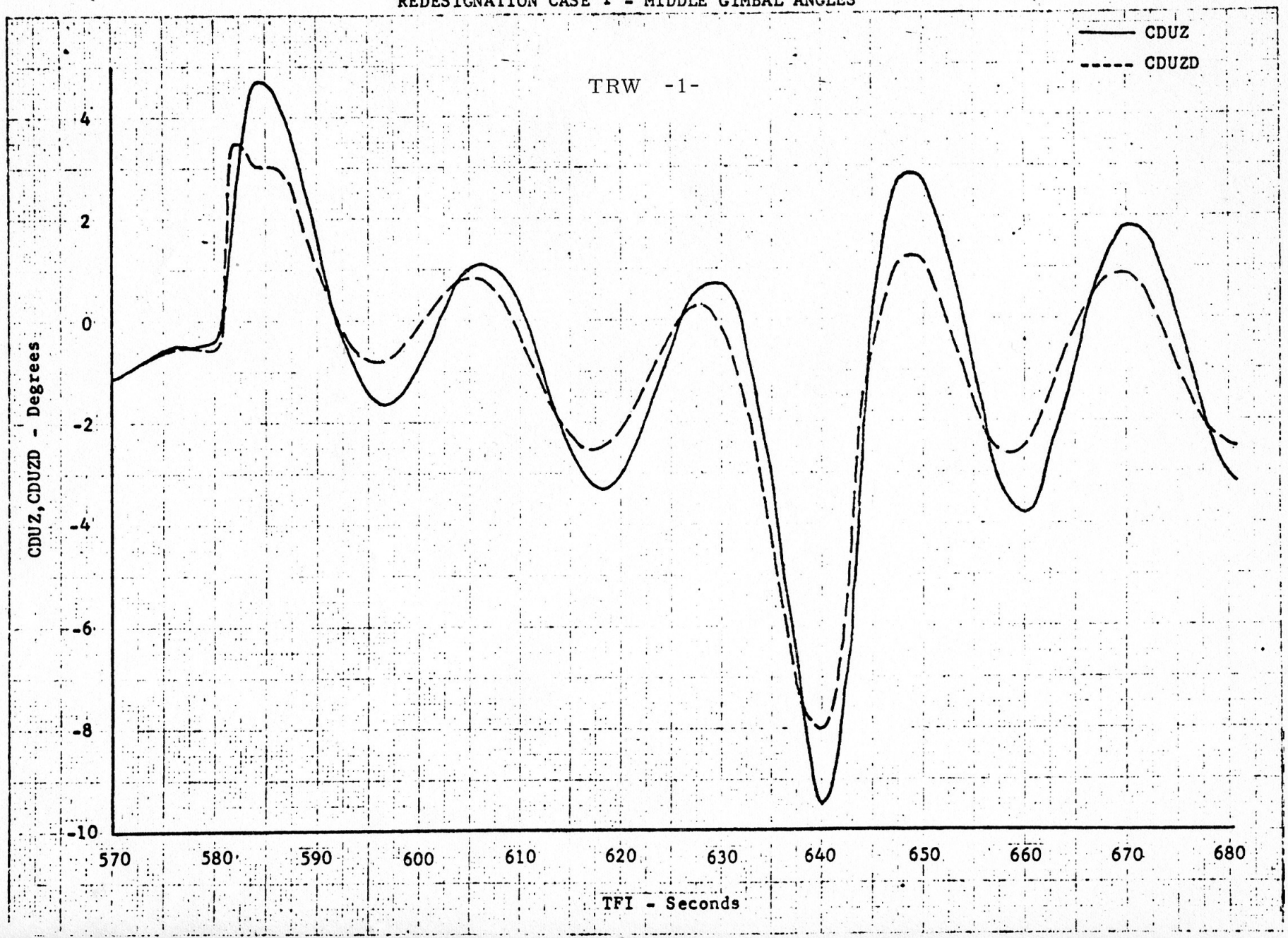
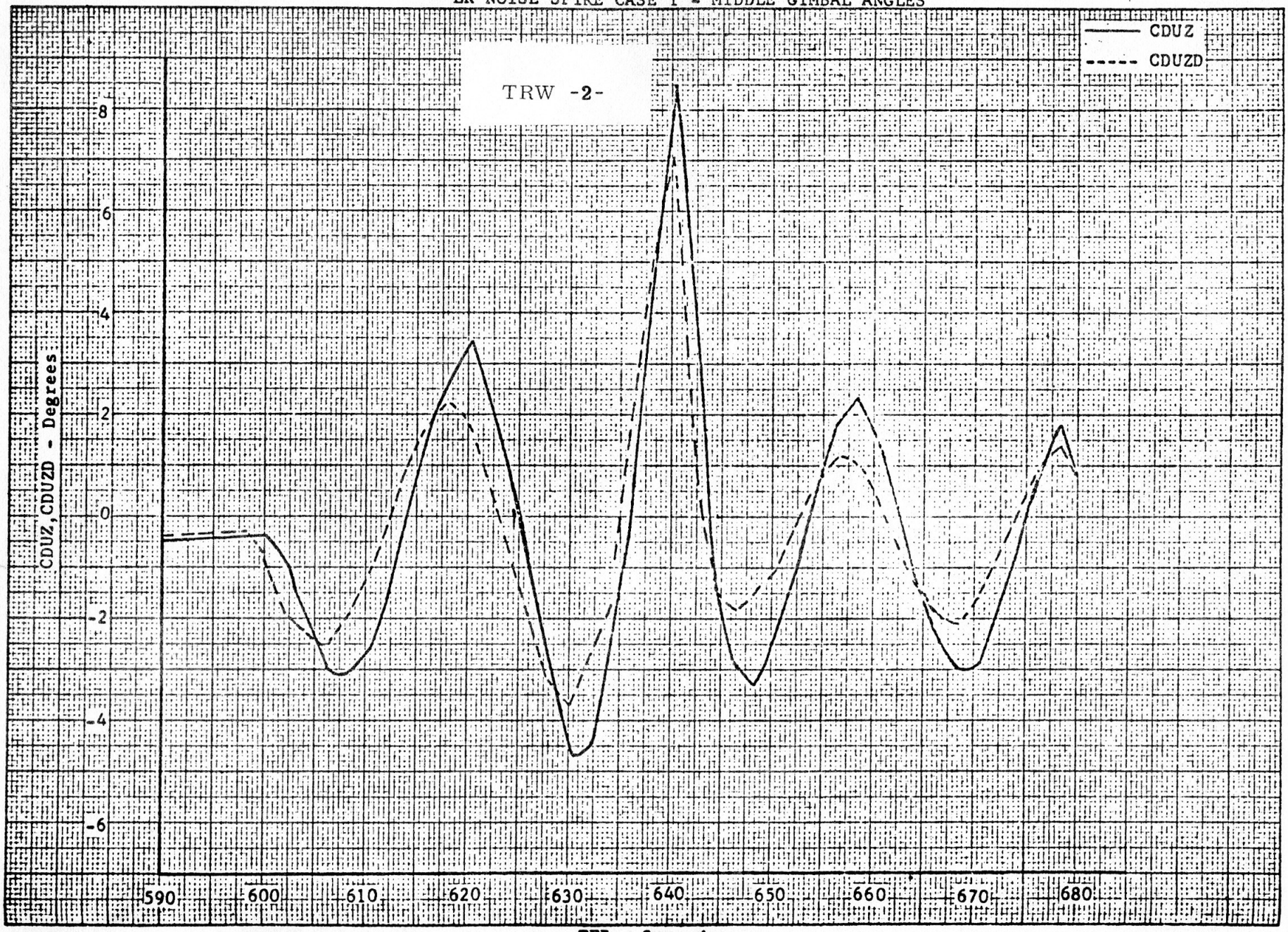


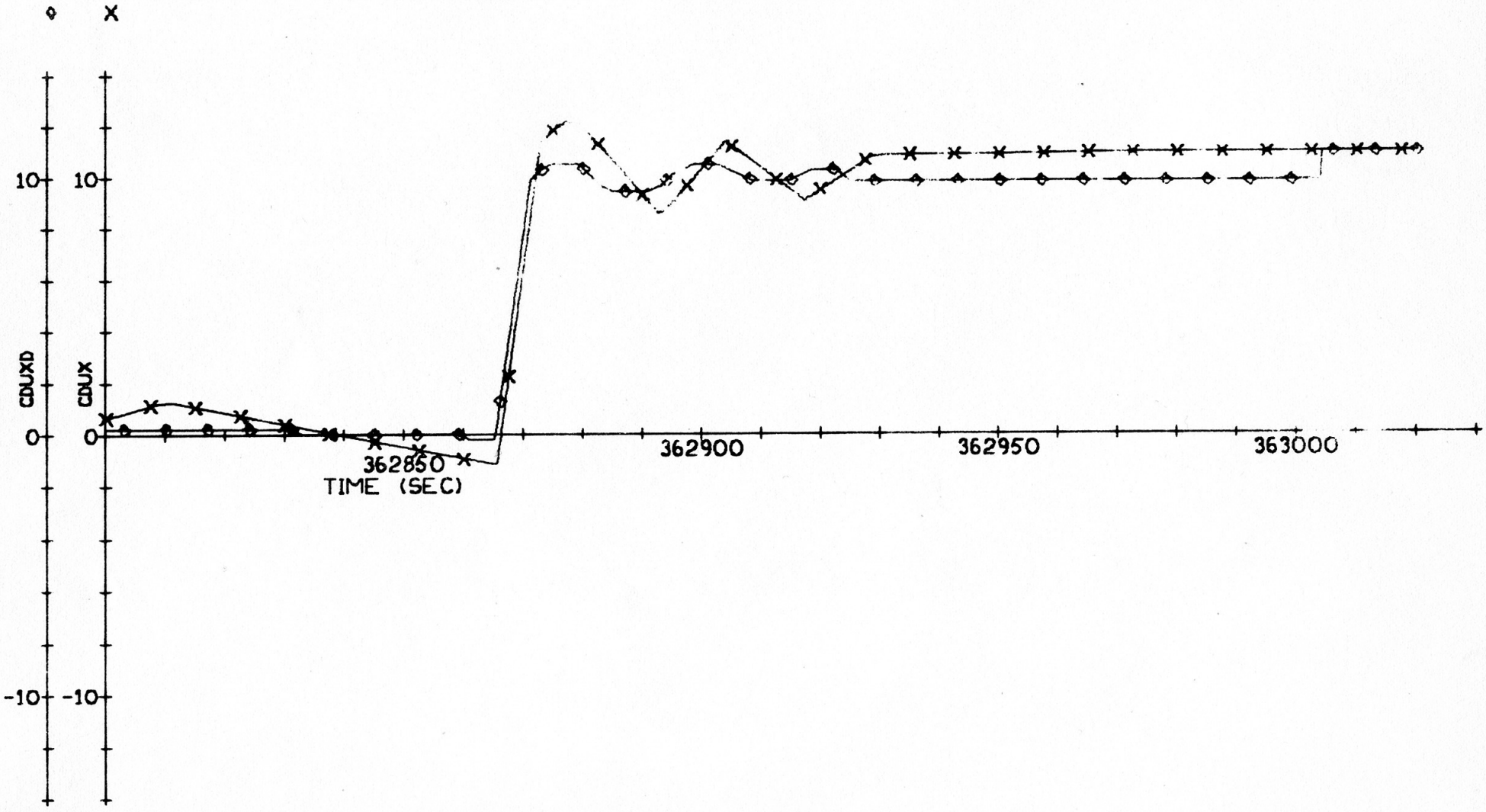
Figure 3


LR NOISE SPIKE CASE 1 - MIDDLE GIMBAL ANGLES
TRW -2-
CDUZ
CDUZD
CDUZ, CDUZD - Degrees
8
6
4
2
0
-2
-4
-6
590
600
610
620
630
640
650
660
670
680
TFI - Seconds

X'S MARK CDUX

◇'S MARK CDUXD

-1-




6DEG REDES, TGO -70, DB 1.0

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P64

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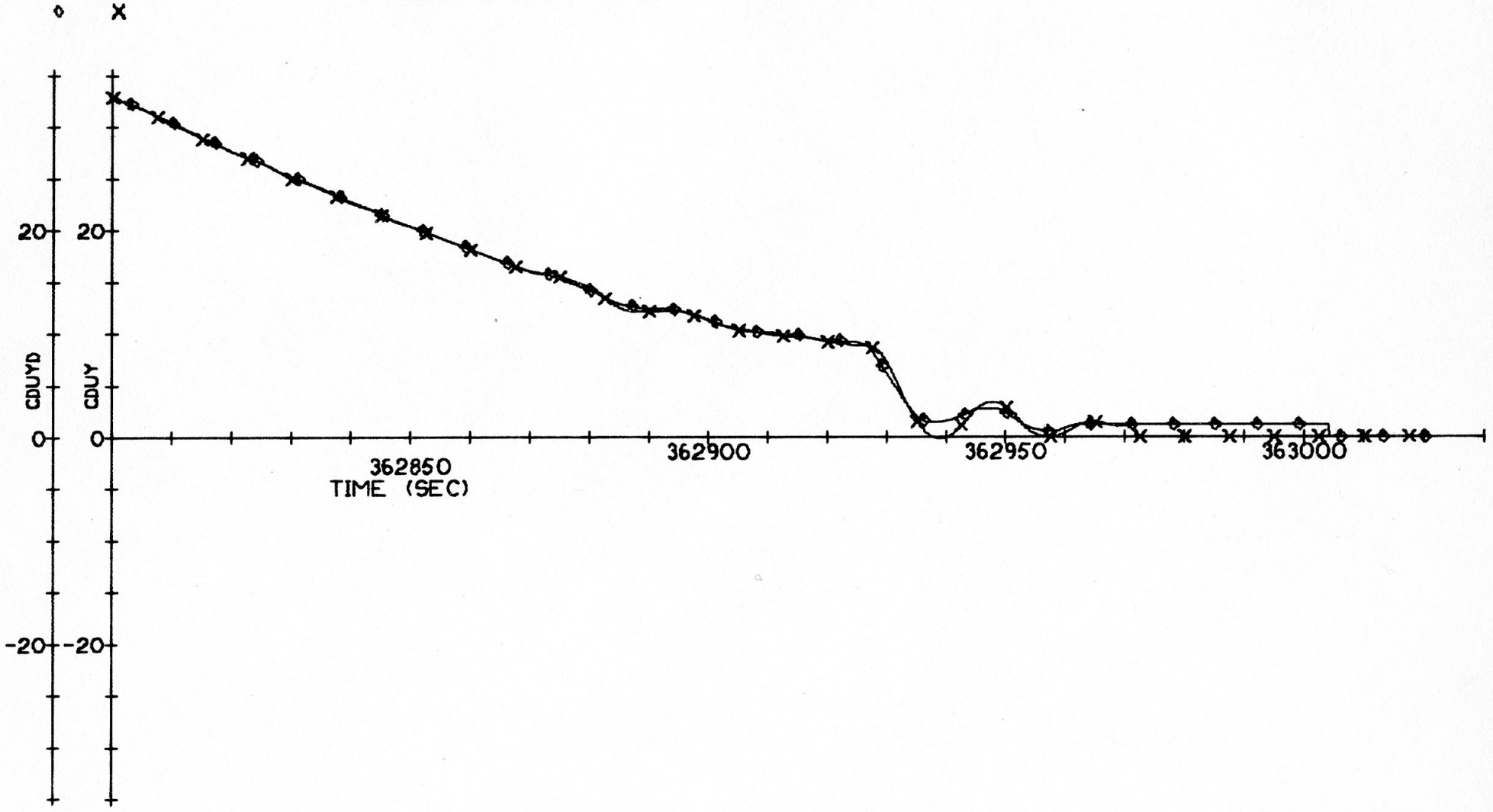
X'S MARK CDUY

◊'S MARK CDUYD

-2-




6DEG REDES, TGO -70, DB 1.0

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P64

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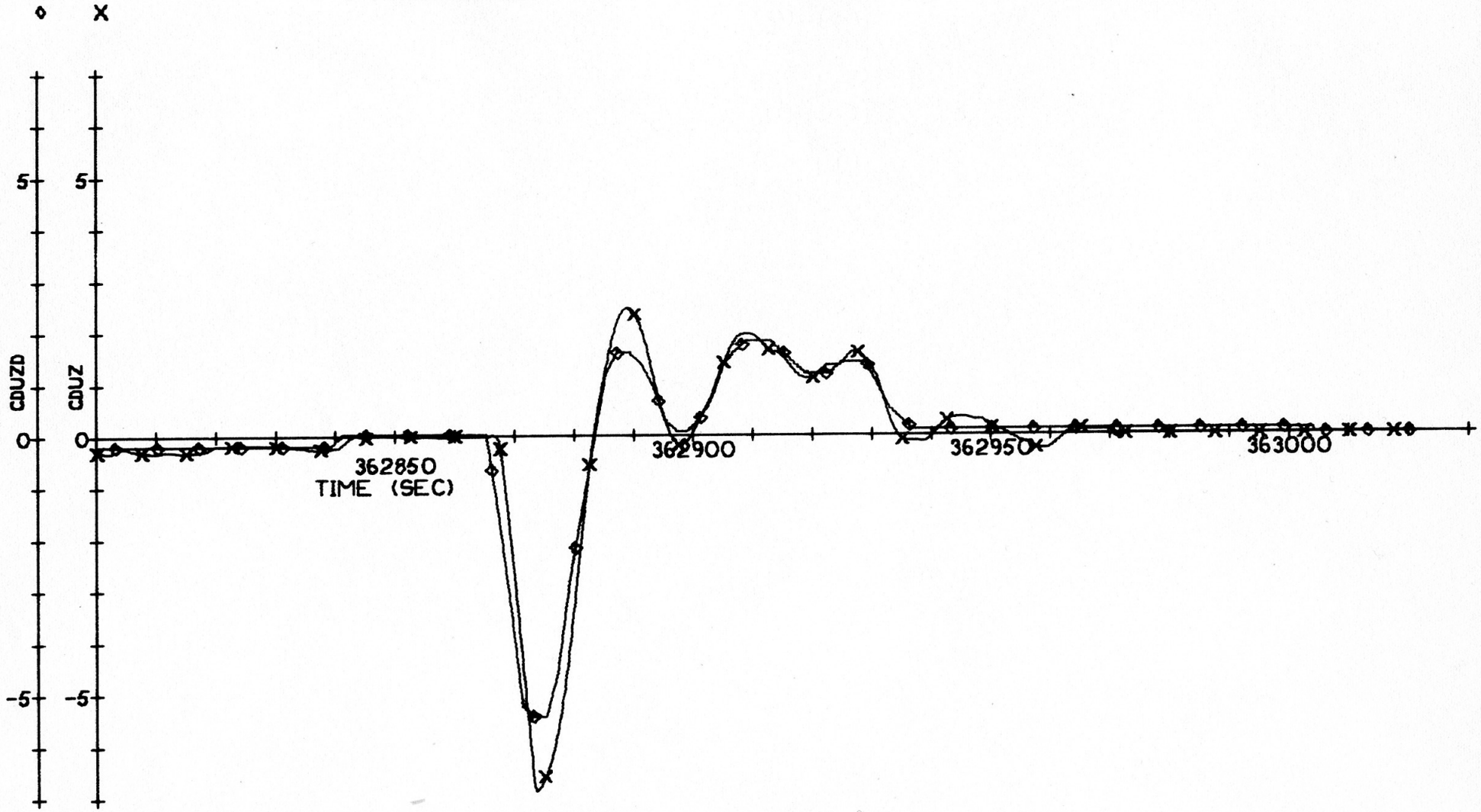
X'S MARK CDUZ

◇'S MARK CDUZD

-3-




6DEG REDES, TGO -70, DB 1.0

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P64

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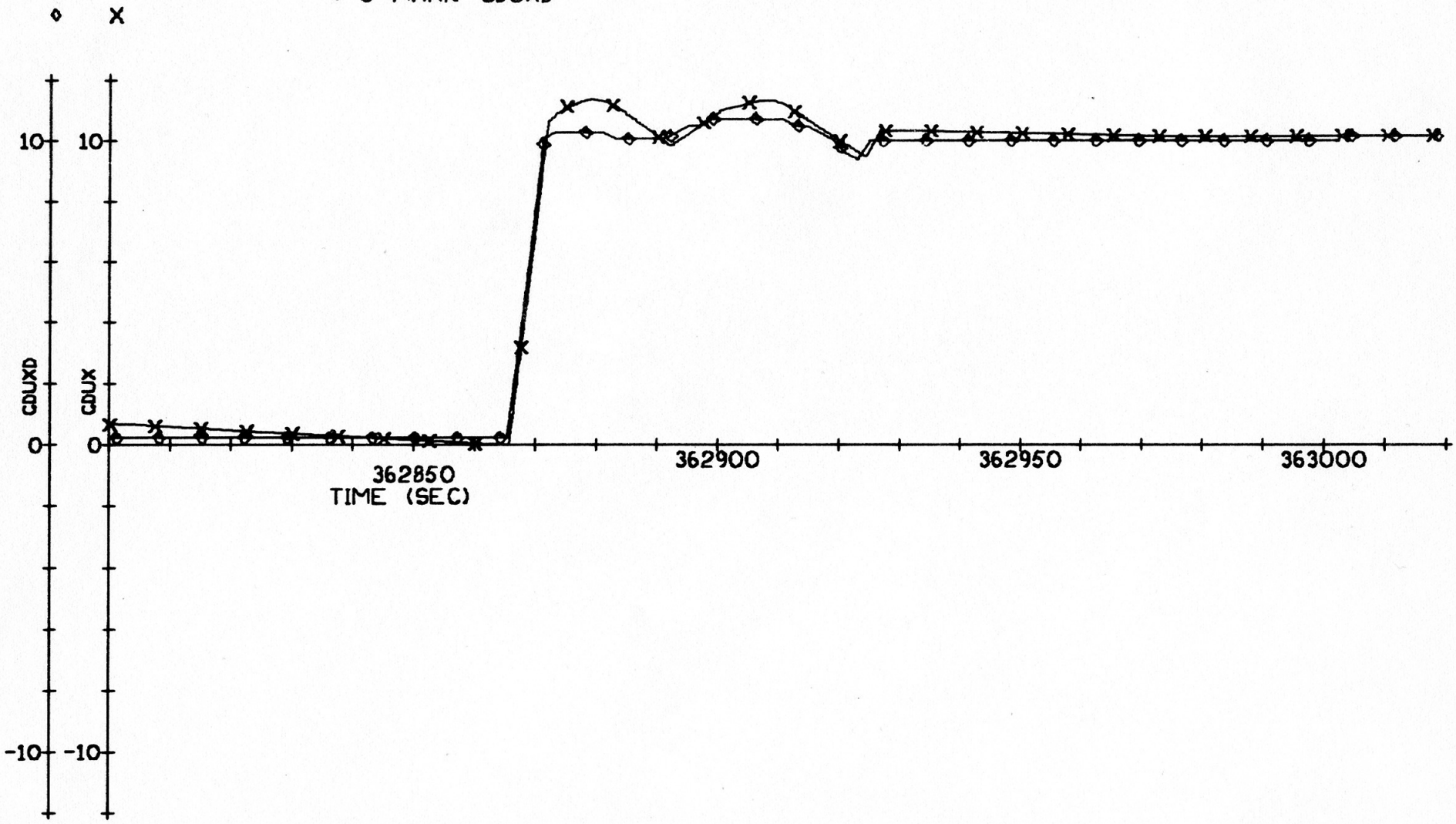
X'S MARK CDUX (-4-)

◇'S MARK CDUXD




6DEG REDES, TGO -70, DB 0.3

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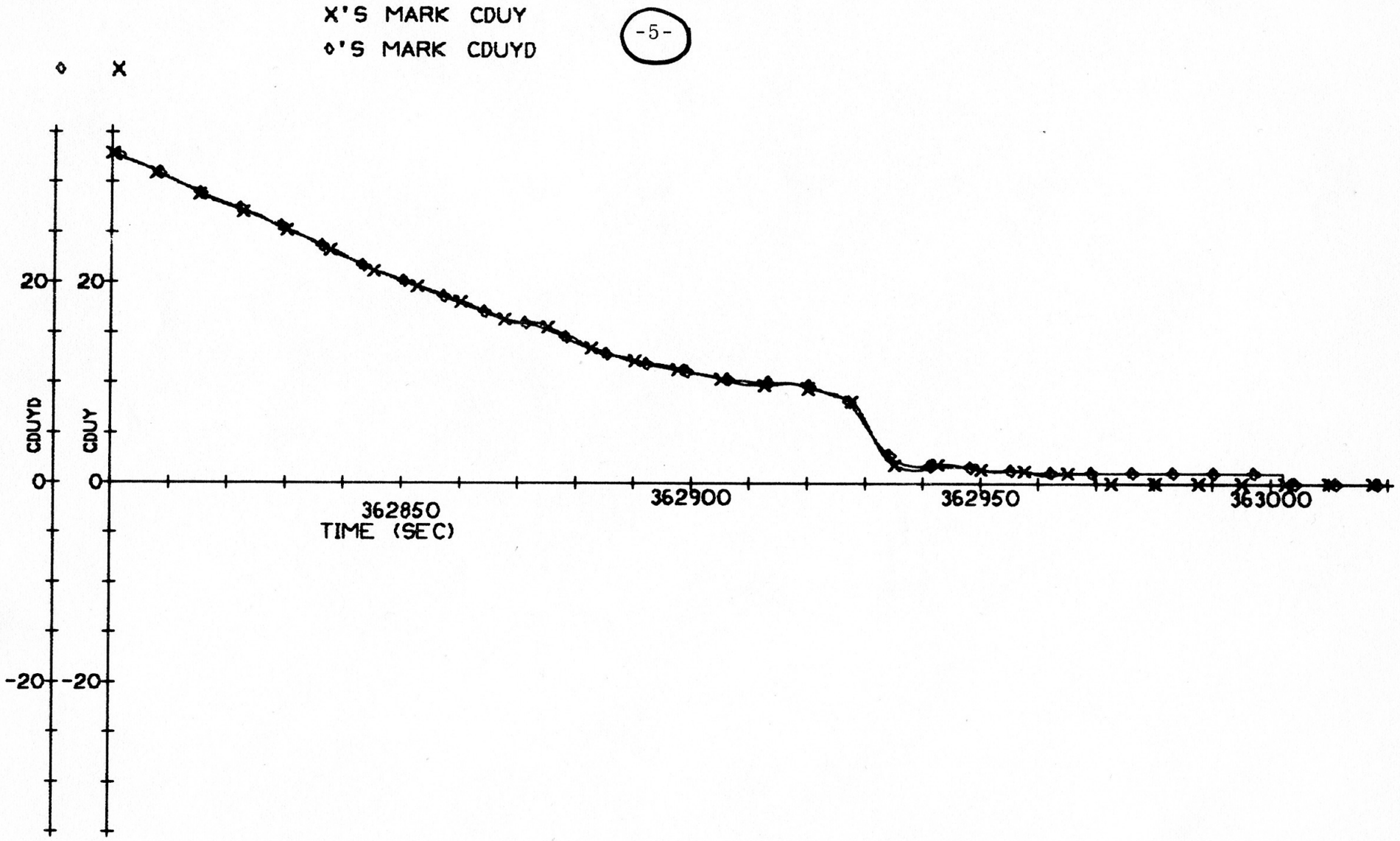
P64

P65




6DEG REDES, TGO -70, DB 0.3

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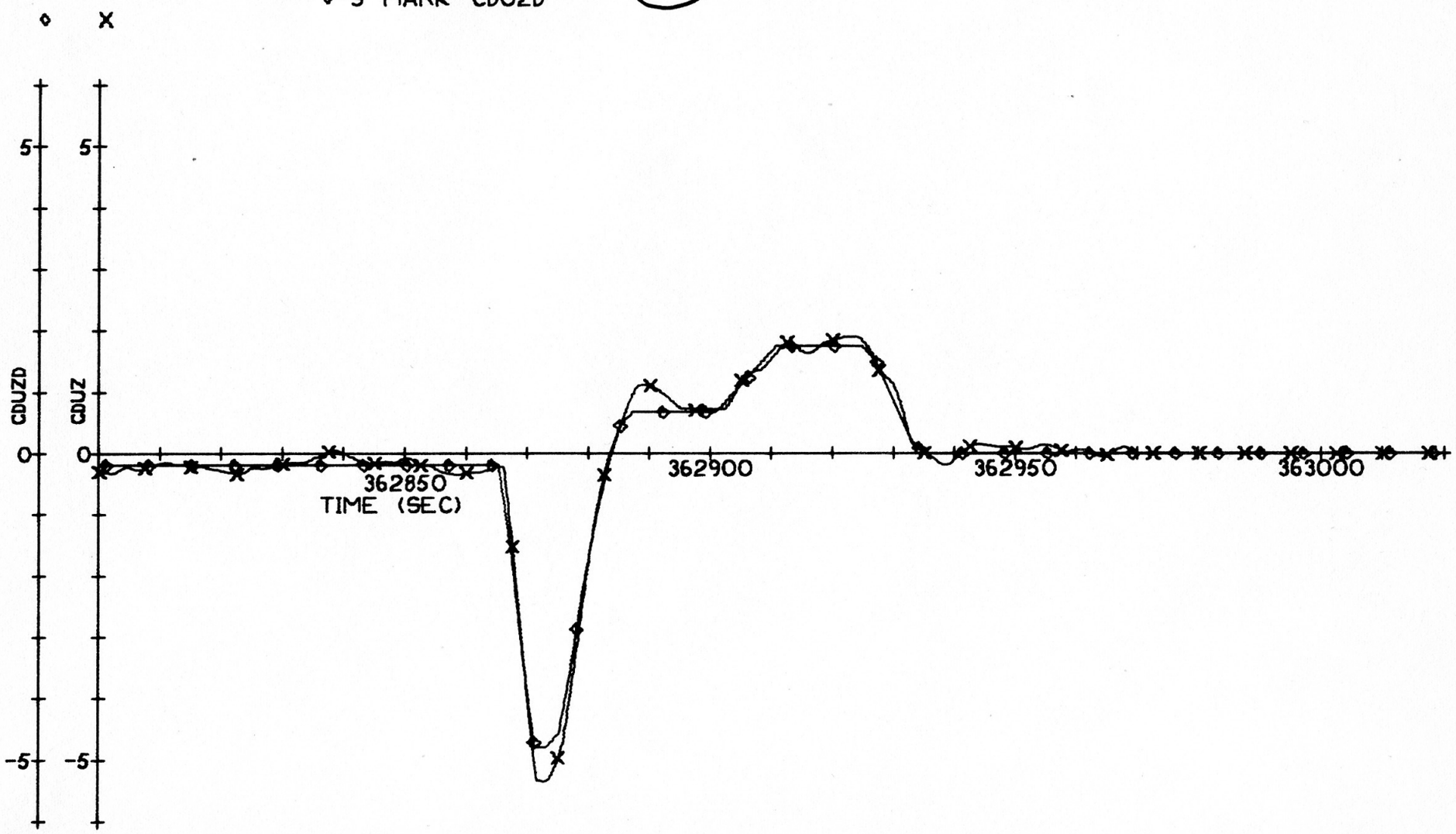
P65




6DEG REDES, TGO -70, DB 0.3

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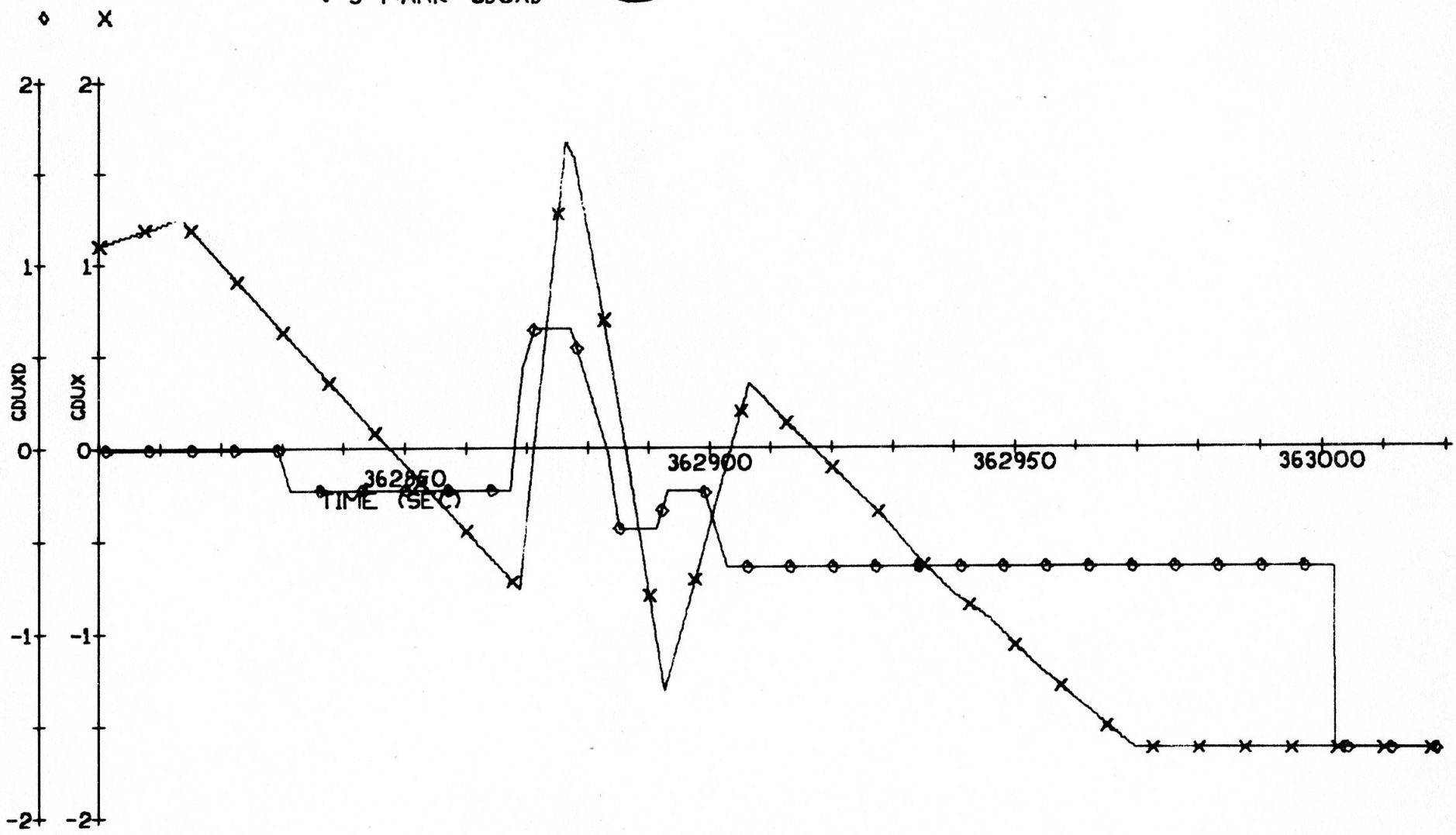
P64

P65

X'S MARK CDUX
◇'S MARK CDUXD




1.5 F/S SPIKE, TGO -70, DB 1.0

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P64

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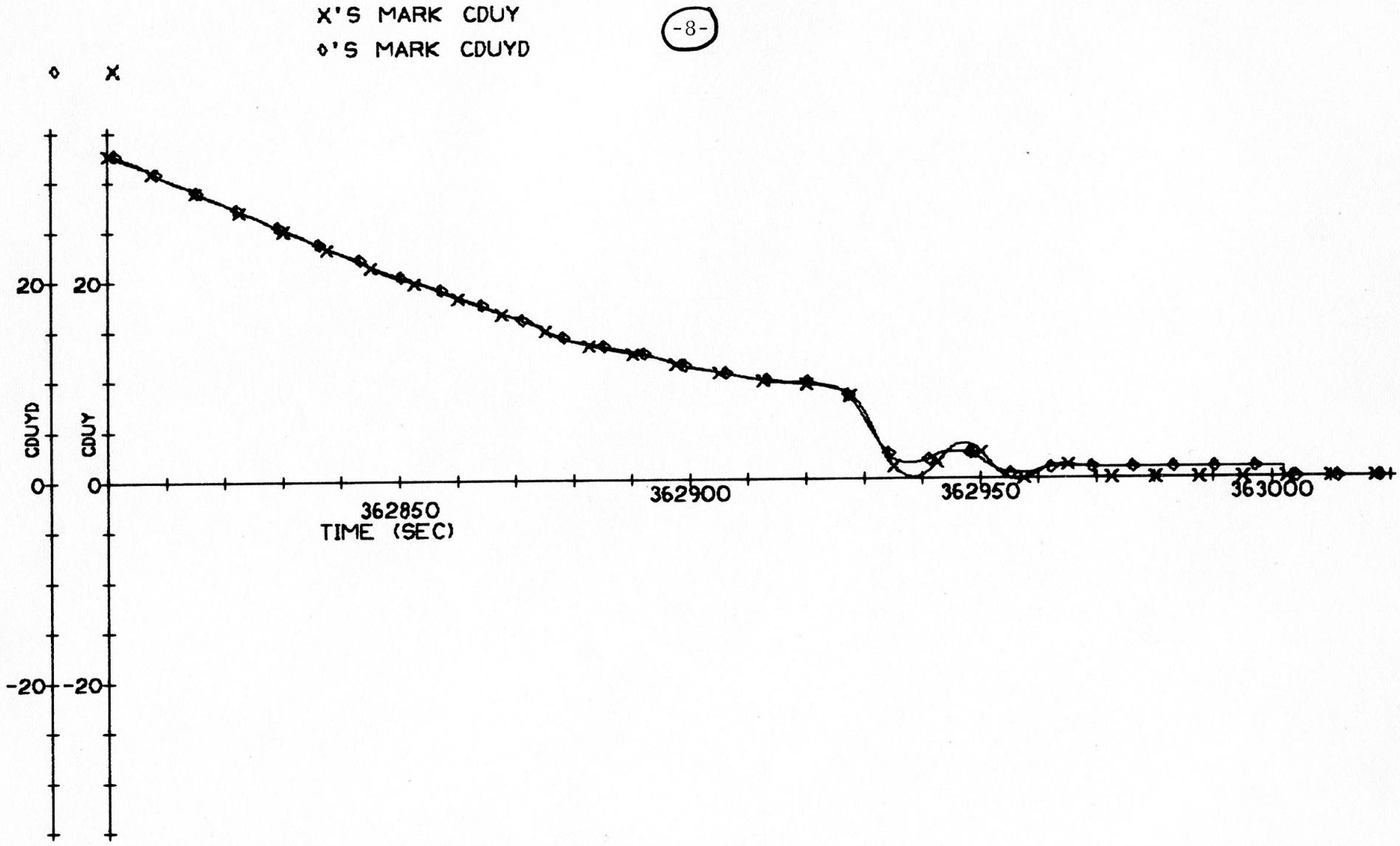


1.5 F/S SPIKE, TGO -70, DB 1.0

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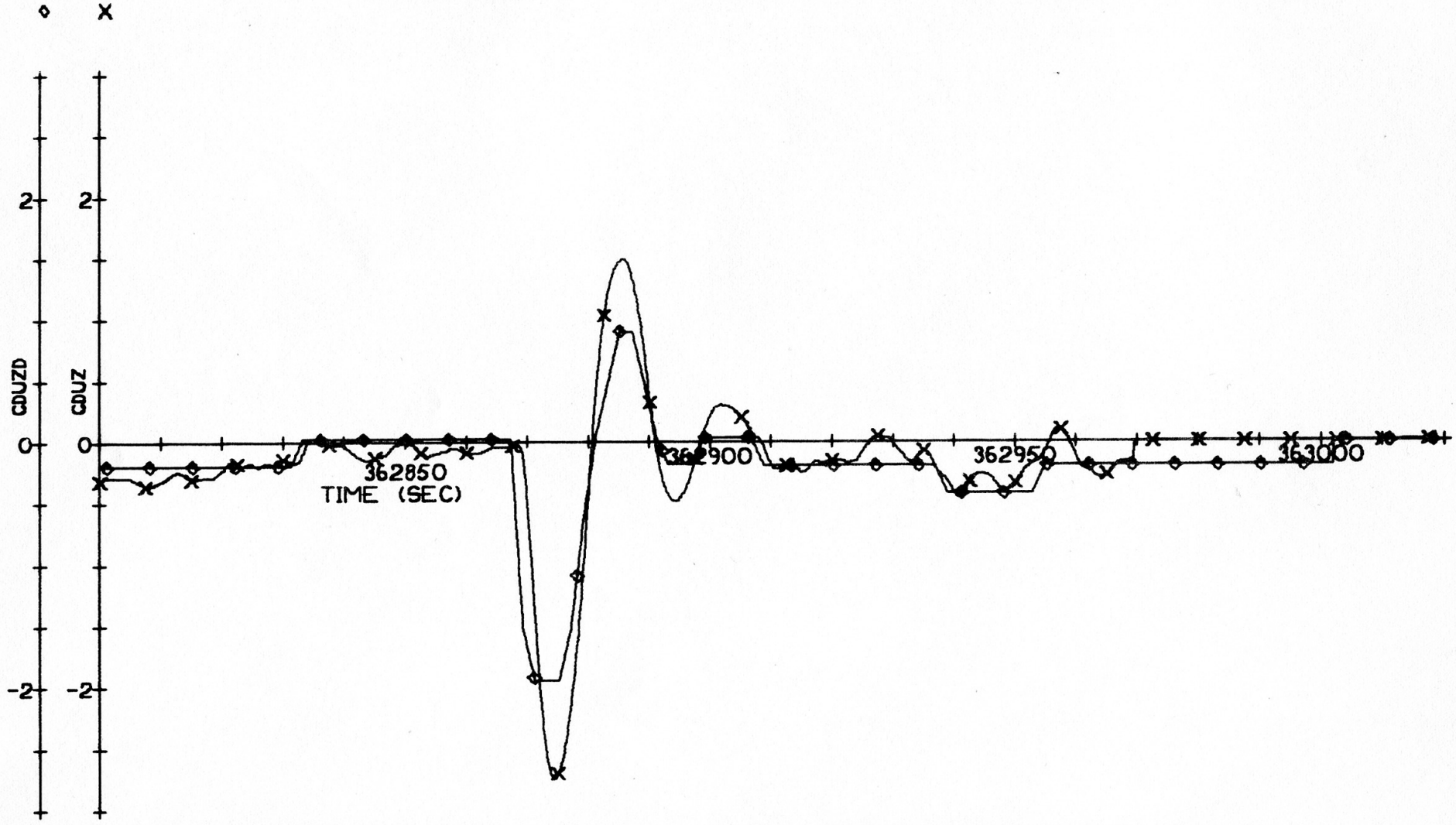
P64

P65

X'S MARK CDUZ
◇'S MARK CDUZD




1.5 F/S SPIKE, TGO -70, DB 1.0

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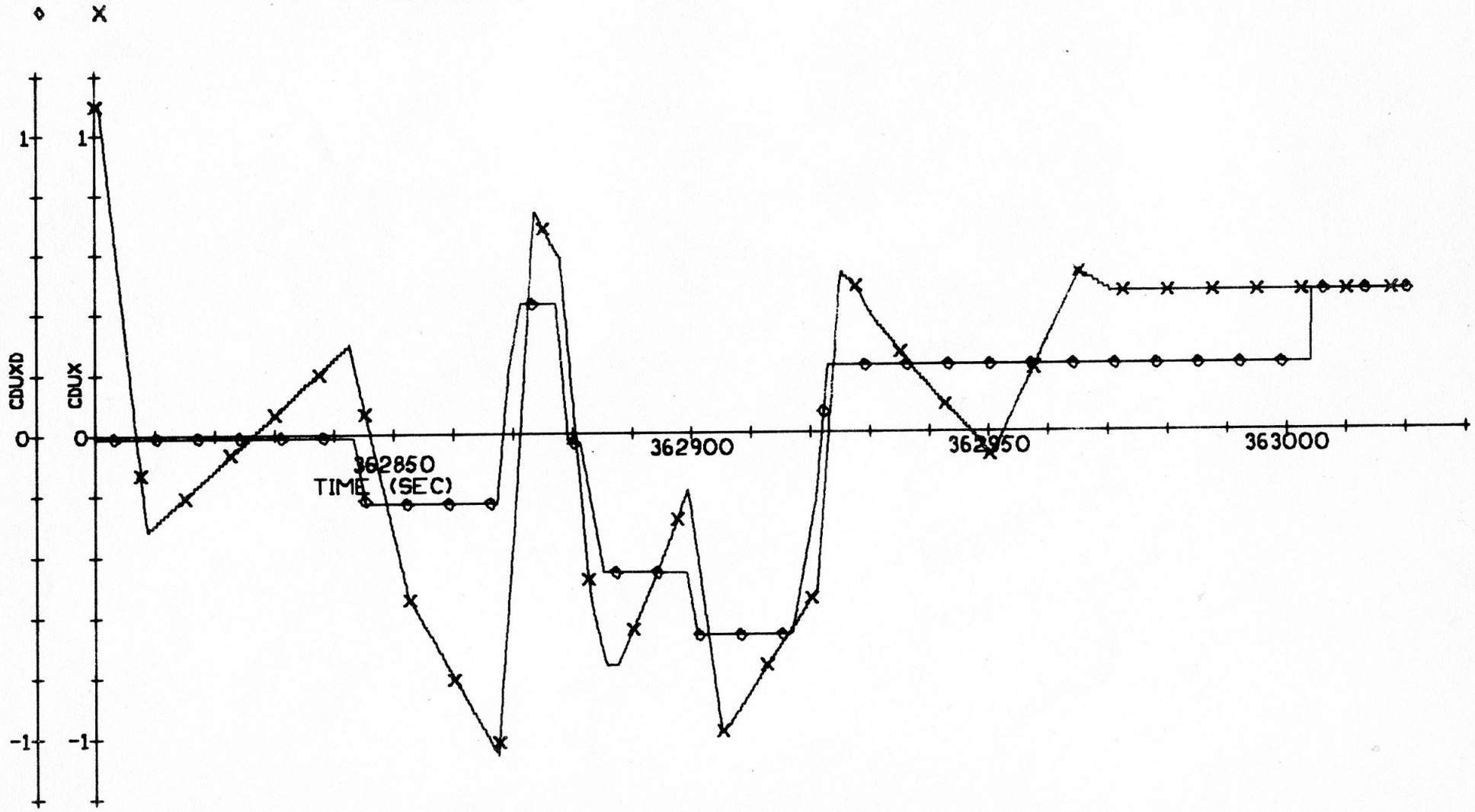
P64

P65

X'S MARK CDUX
◇'S MARK CDUXD




1.5 F/S SPIKE, TGO -70, DB 0.3

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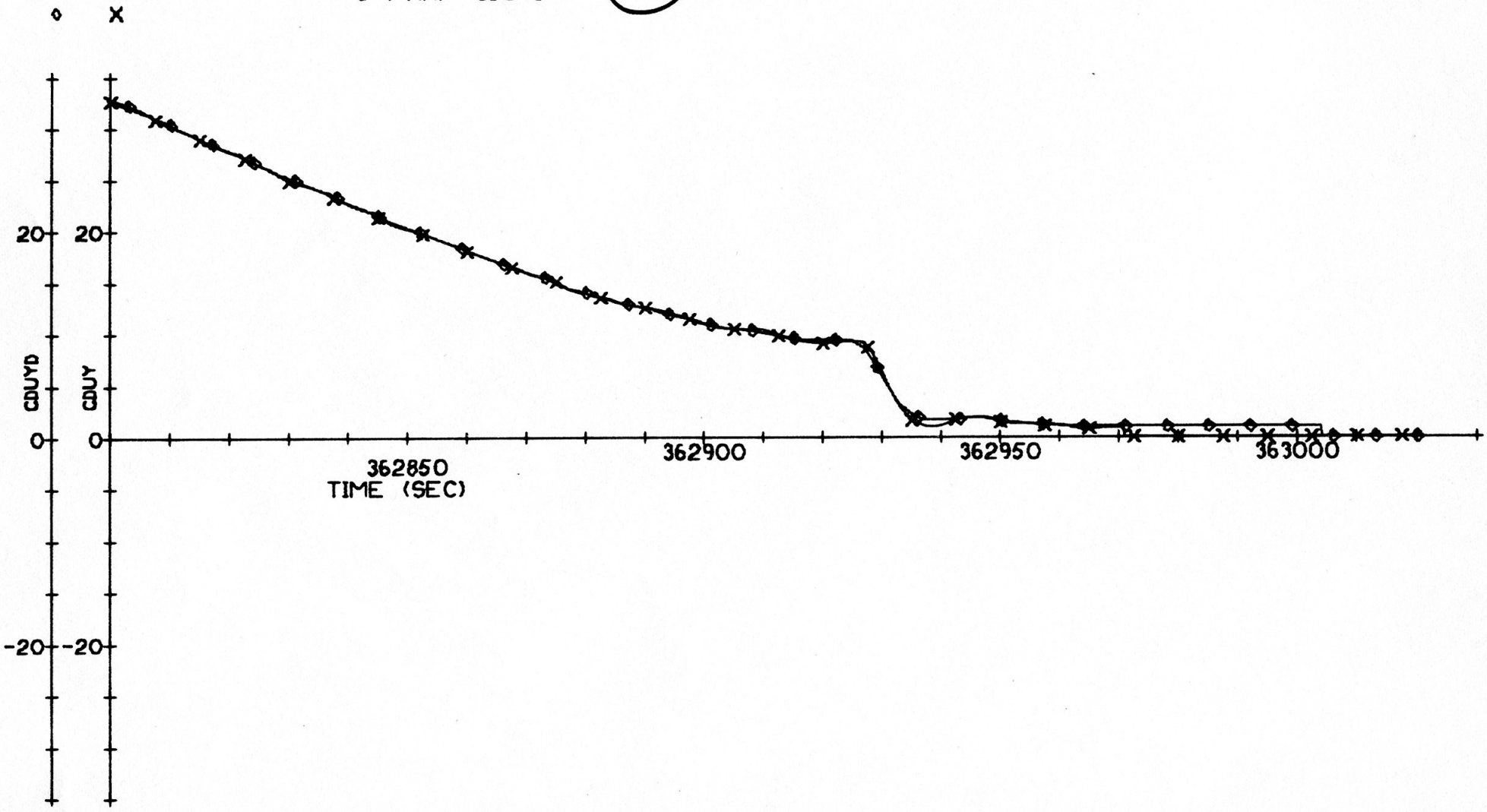
P64

P65

X'S MARK CDUY
◊'S MARK CDUYD

-11-




1.5 F/S SPIKE, TGO -70, DB 0.3

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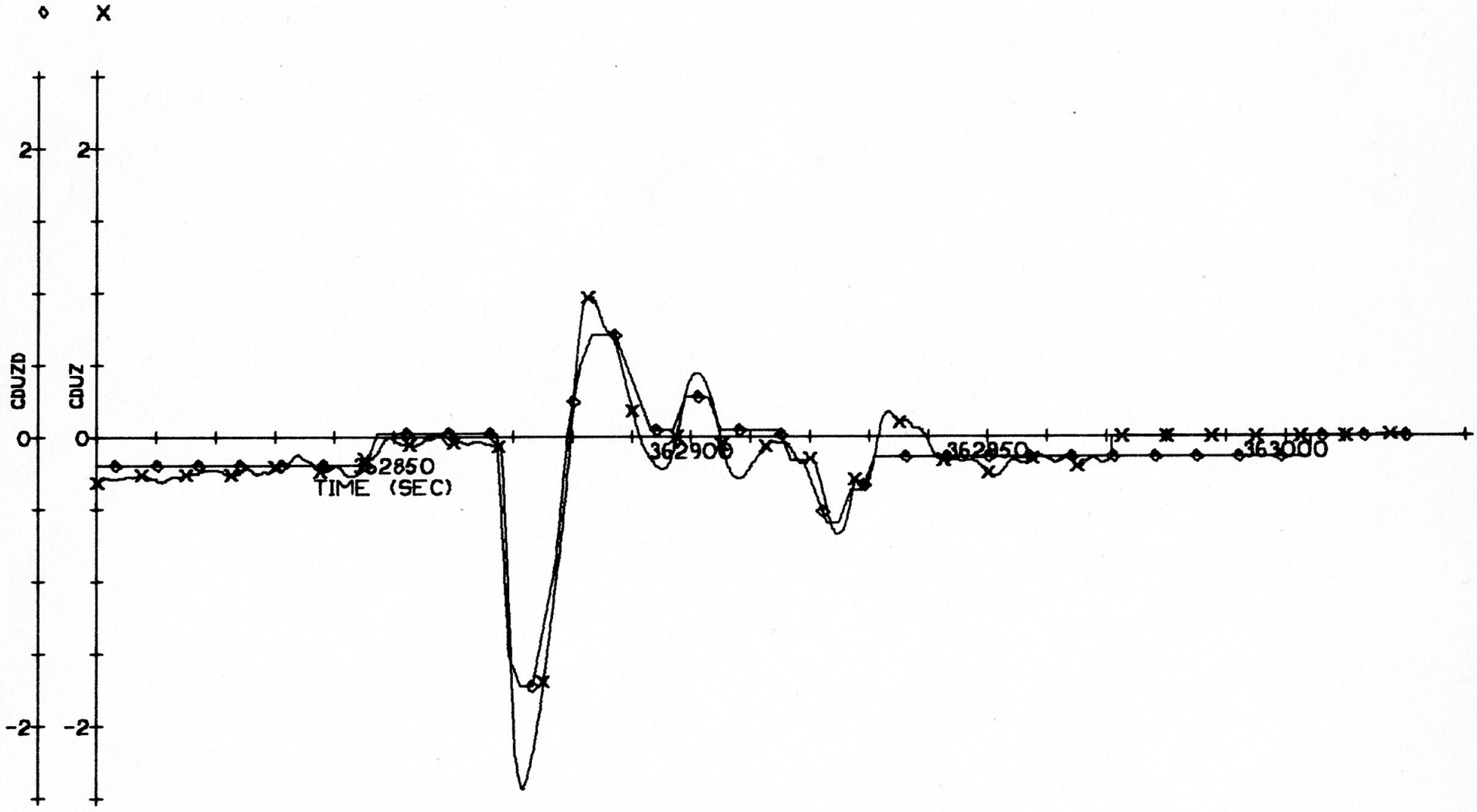
P64

P65

X'S MARK CDUZ
◇'S MARK CDUZD




1.5 F/S SPIKE, TGO -70, DB 0.3

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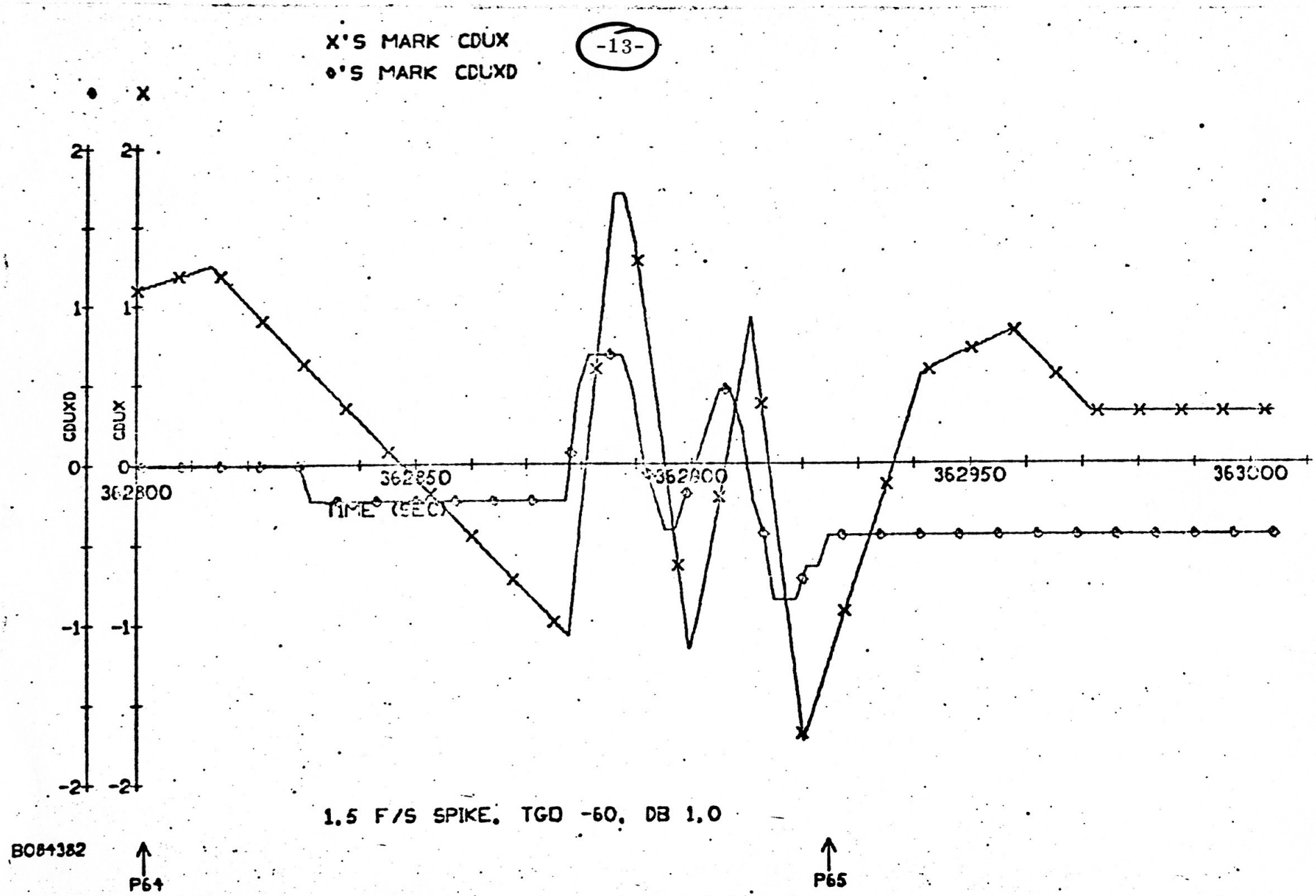
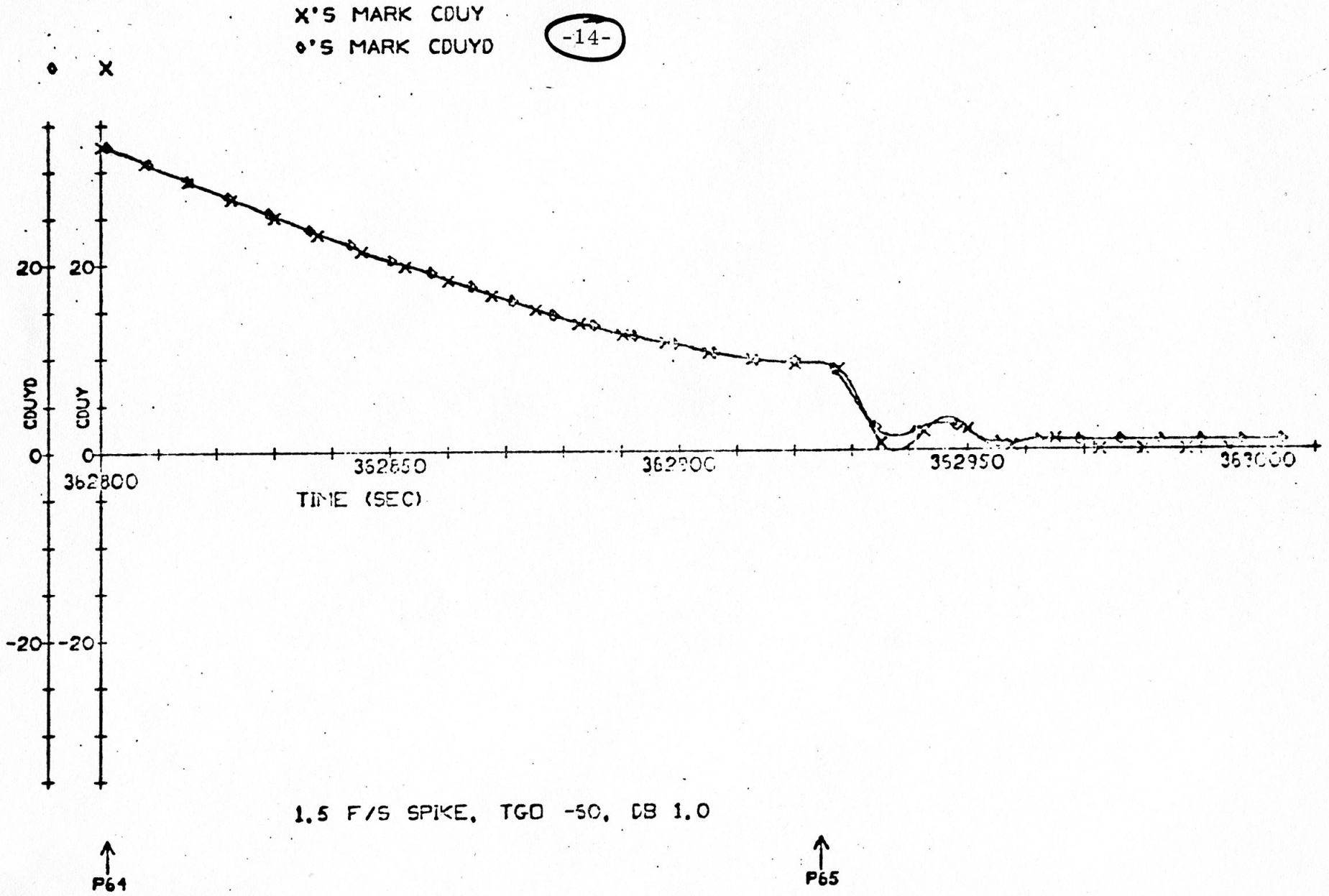
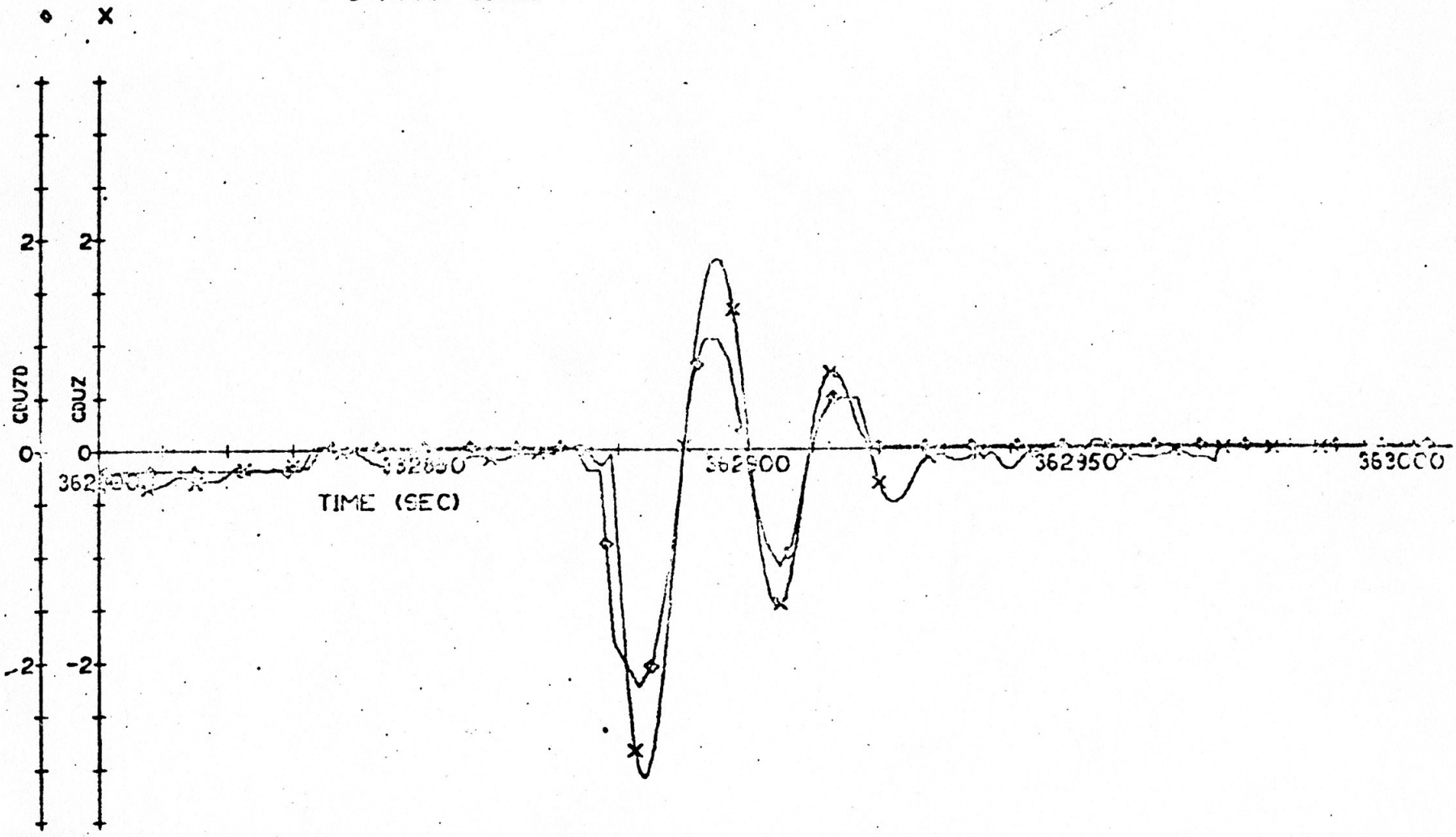

X'S MARK CDUX
•'S MARK CDUXD
• X
2
1
0
-1
-2
CDUXD
CDUX
362800
362850
362900
362950
363000
TIME (SEC)
1.5 F/S SPIKE. TGO -60, DB 1.0
B084382
P64
P65


X'S MARK CDUY
0'S MARK CDUYD
0 X
20
20
0
0
-20
-20
CDUYD
CDUY
362800
362850
362900
362950
363000
TIME (SEC)
1.5 F/S SPIKE, TGO -50, DB 1.0
P64
P65

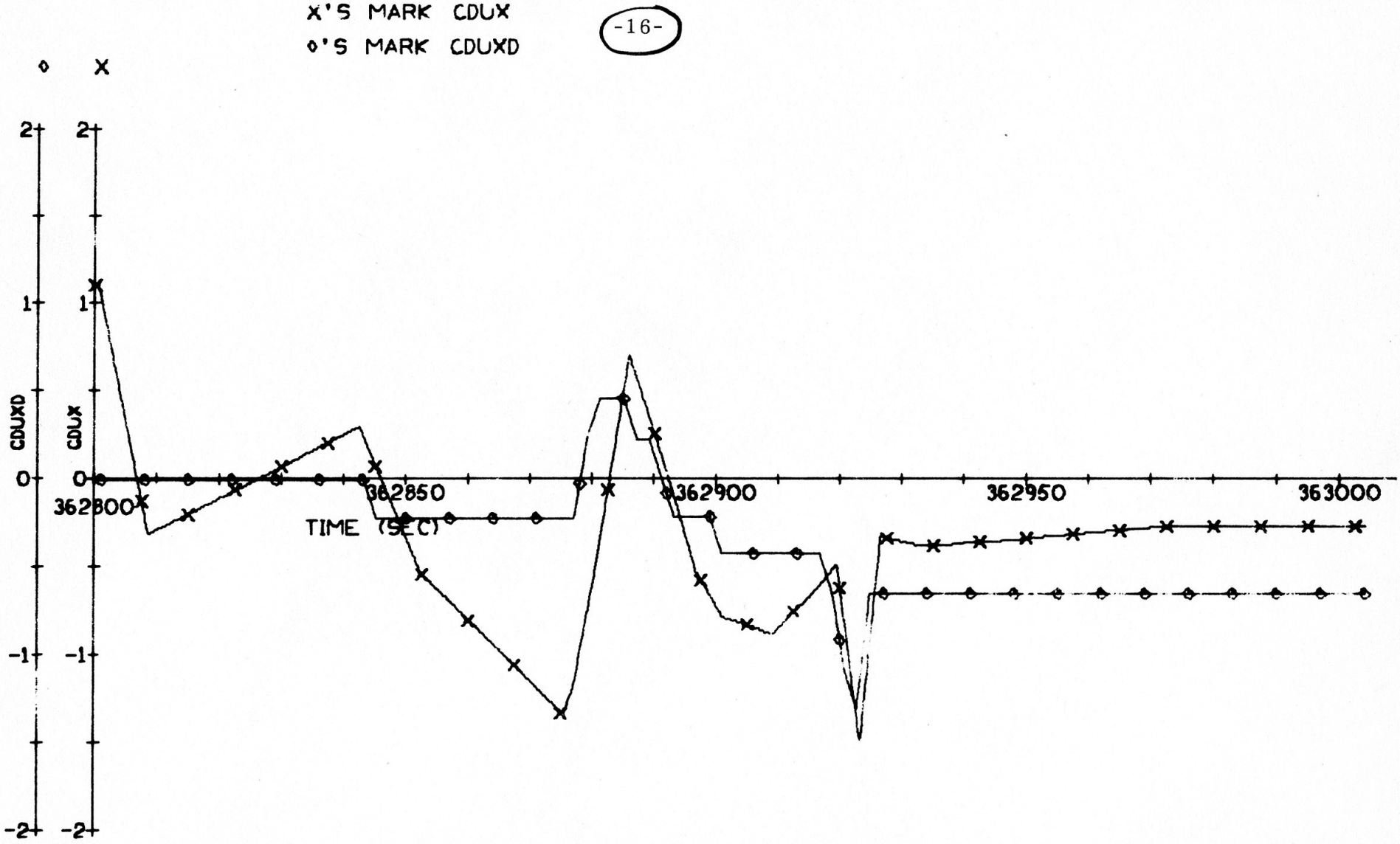
X'S MARK CDUZ
◇'S MARK CDUZD




1.5 F/S SPIKE, TGO -60, DB 1.0

P64

P65




1.5 F/S SPIKE, TGO -60, DB 0.3

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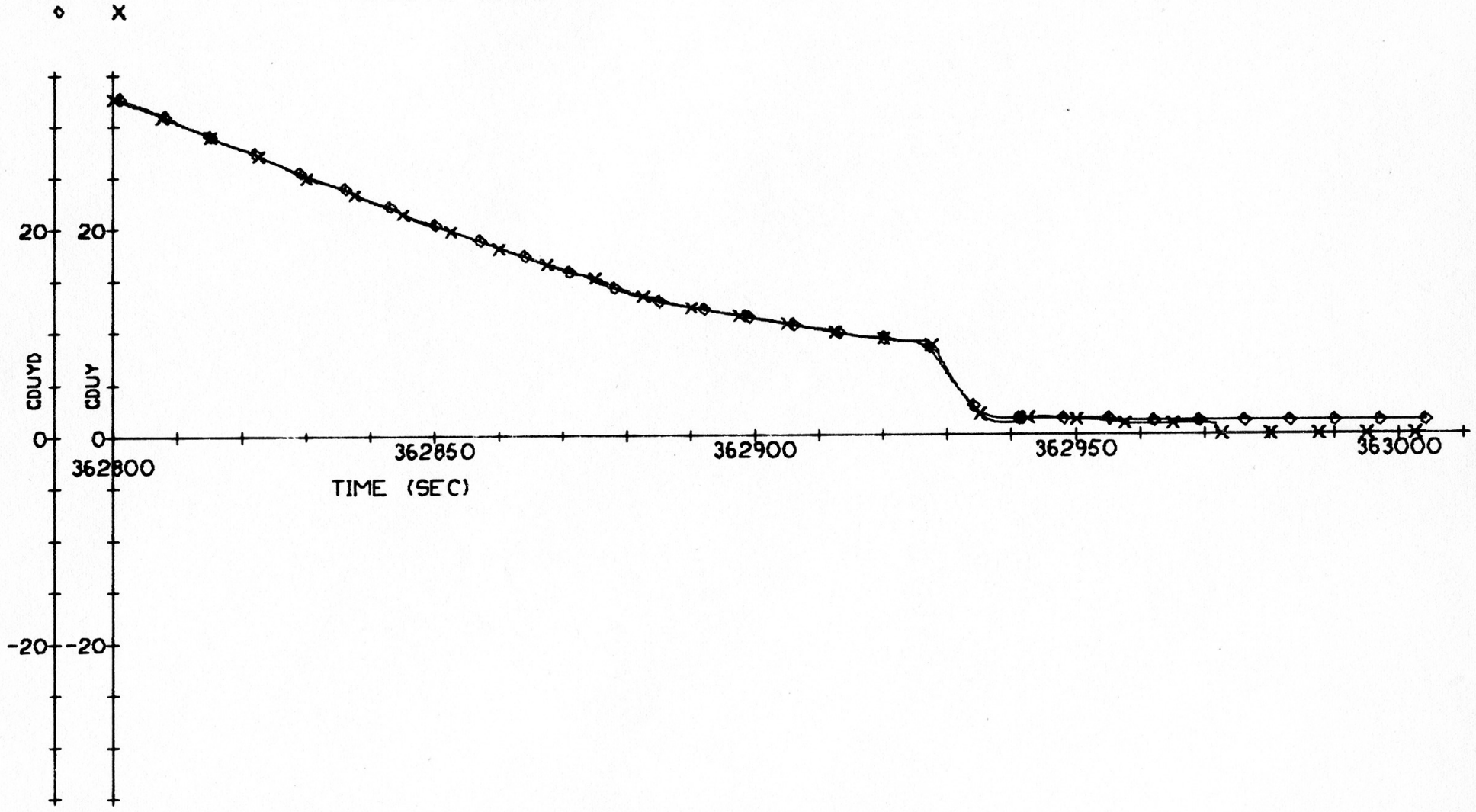
P64

P65



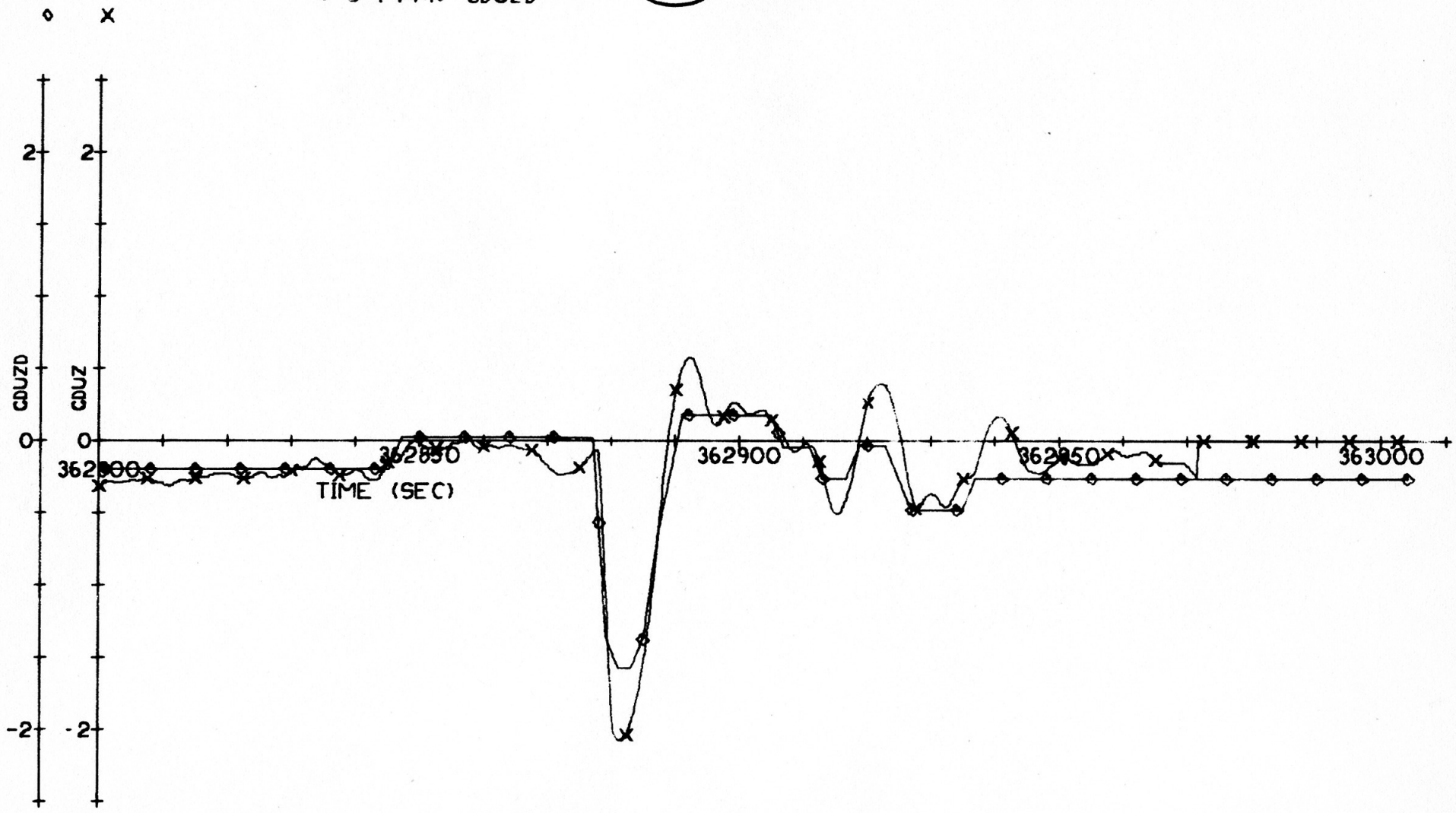

1.5 F/S SPIKE, TGO -60, DB 0.3

B084411

P64

P65

X'S MARK CDUZ
◇'S MARK CDUZD




1.5 F/S SPIKE, TGO -60, DB 0.3

B084411

P64

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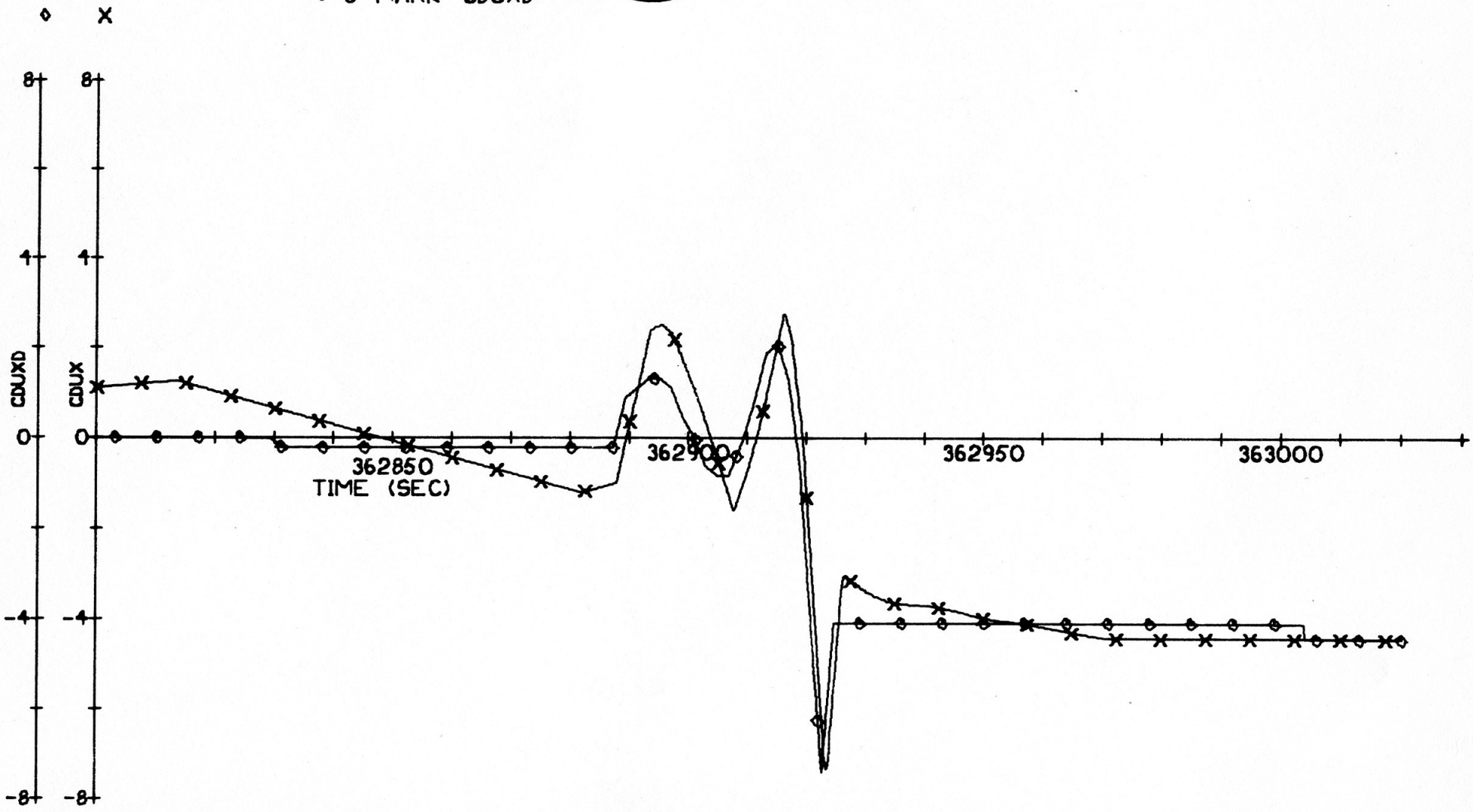
X'S MARK CDUX
◇'S MARK CDUXD

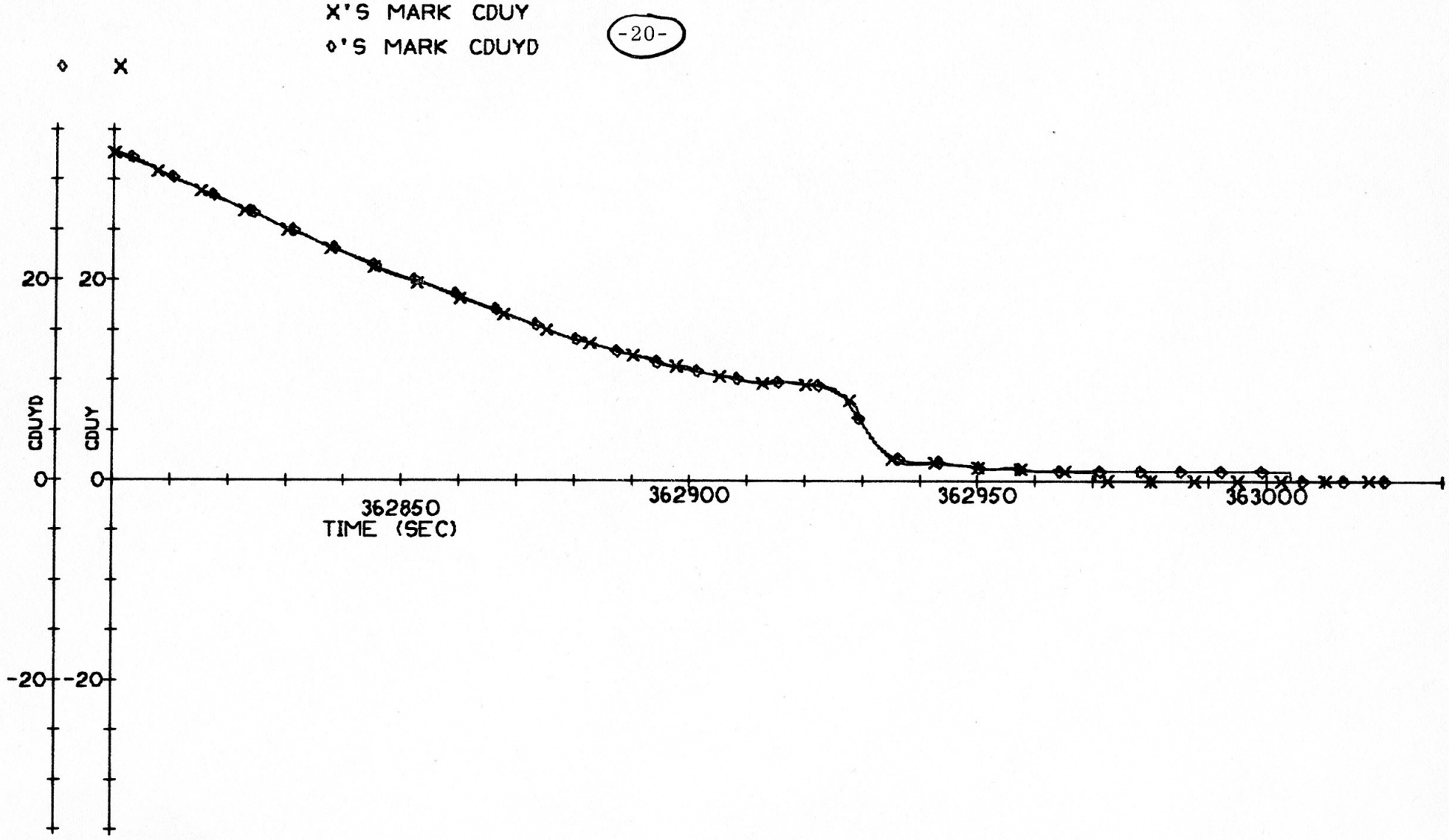



1.5 F/S SPIKE, TGO -50, DB 1.0

B084259

P64

P65




1.5 F/S SPIKE, TGO -50, DB 1.0

B084259

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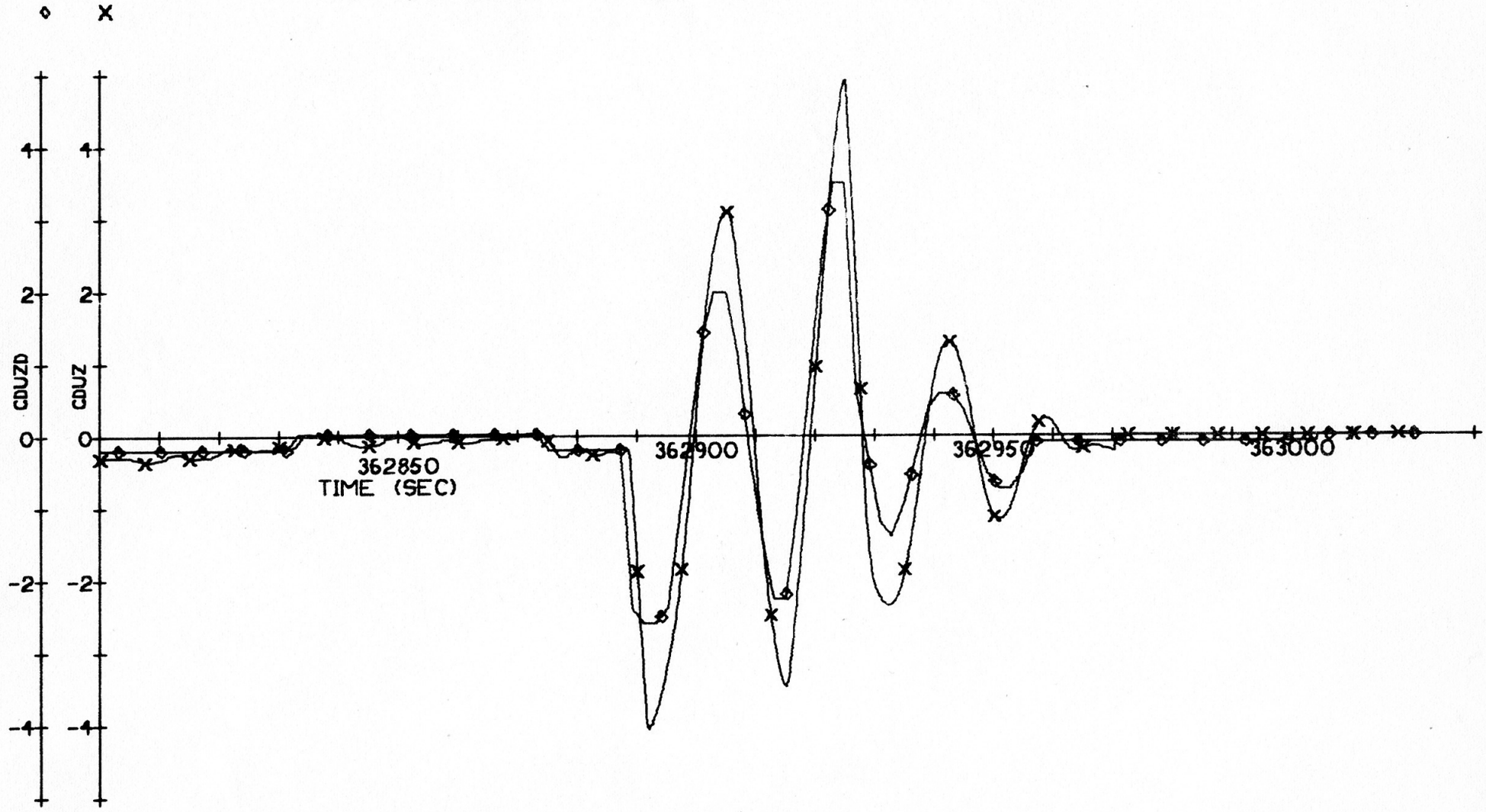


1.5 F/S SPIKE, TGO -50, DB 1.0

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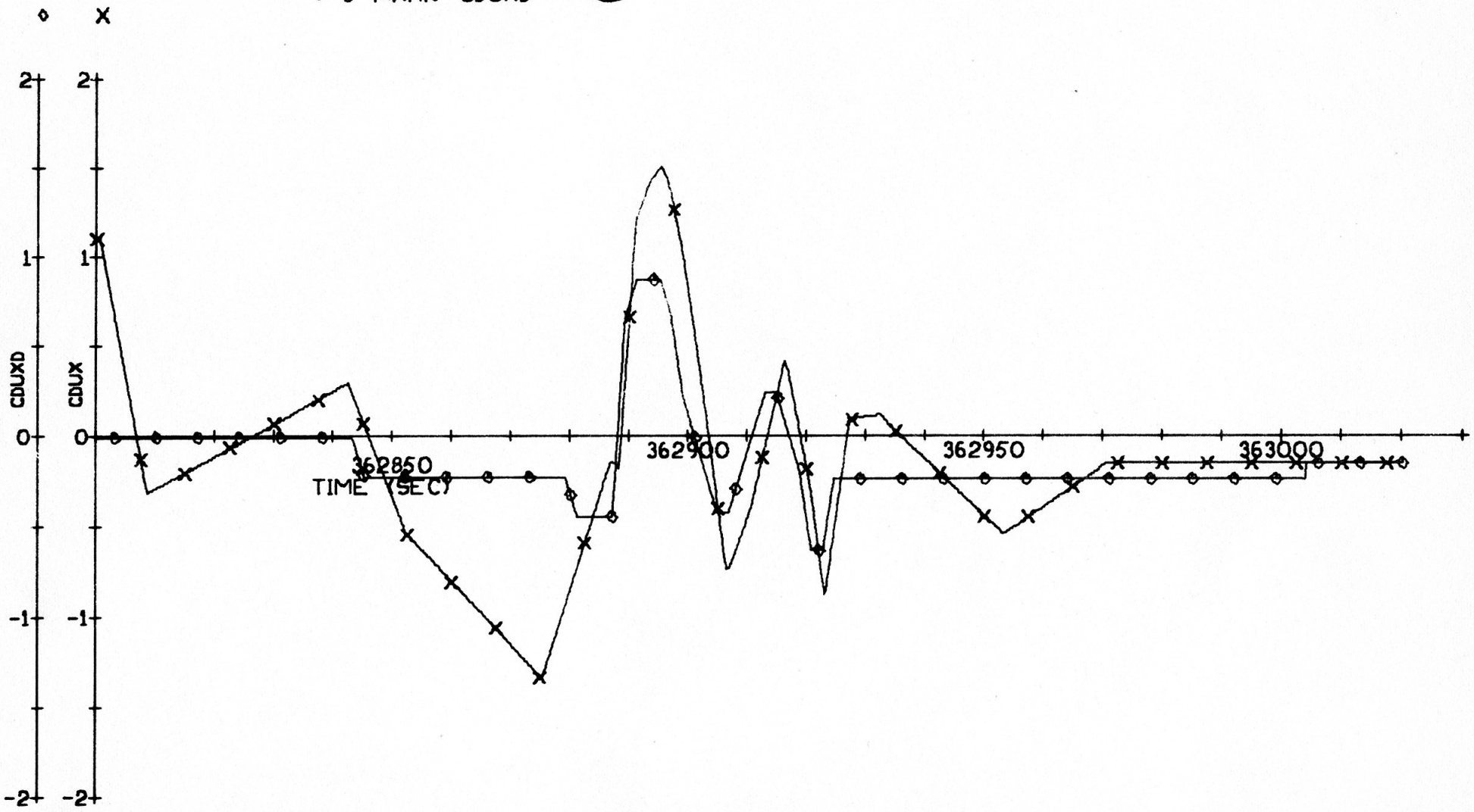
X'S MARK CDUX
◊'S MARK CDUXD






1.5 F/S SPIKE, TGO -50, DB 0.3

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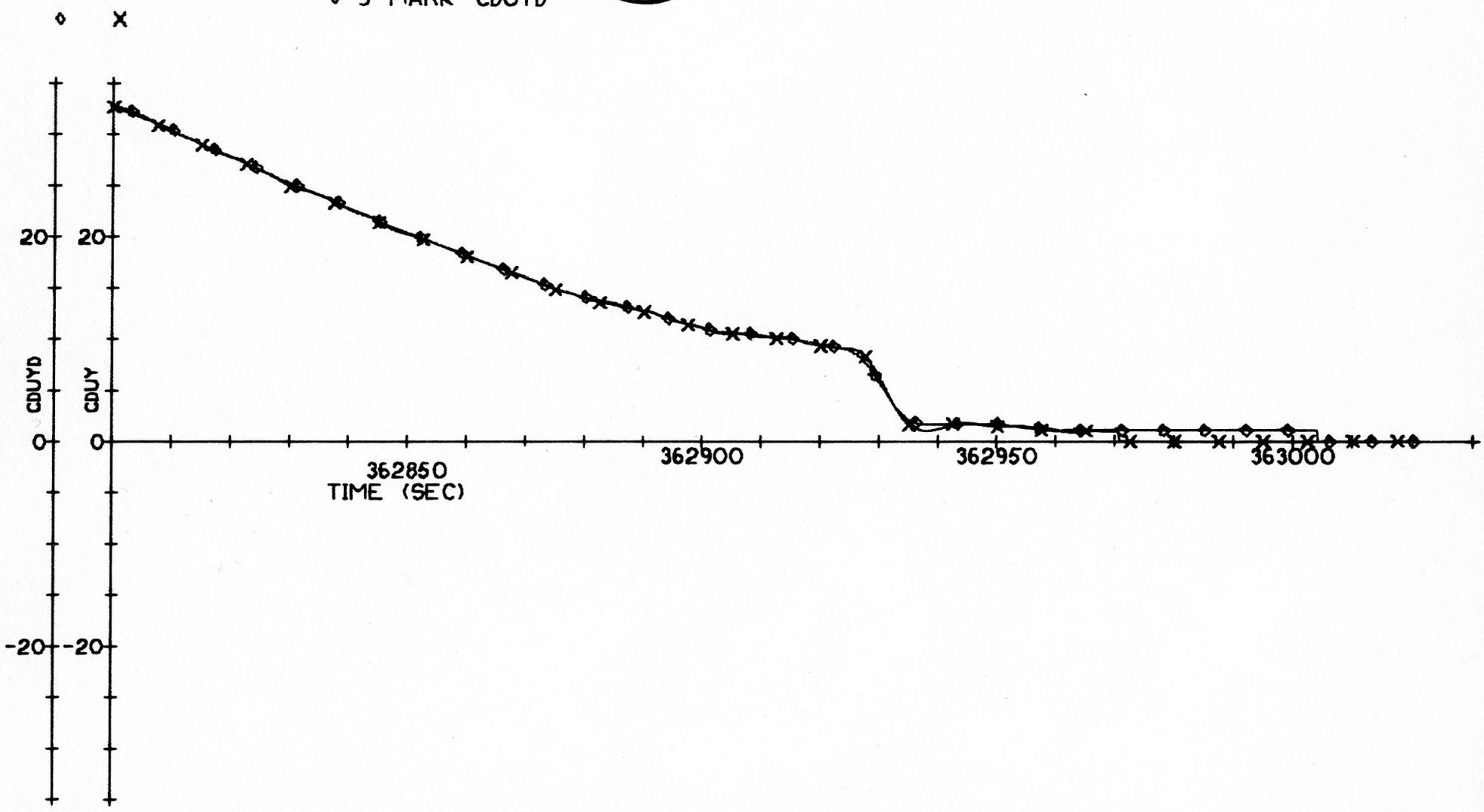
X'S MARK CDUY
◊'S MARK CDUYD






1.5 F/S SPIKE, TGO -50, DB 0.3

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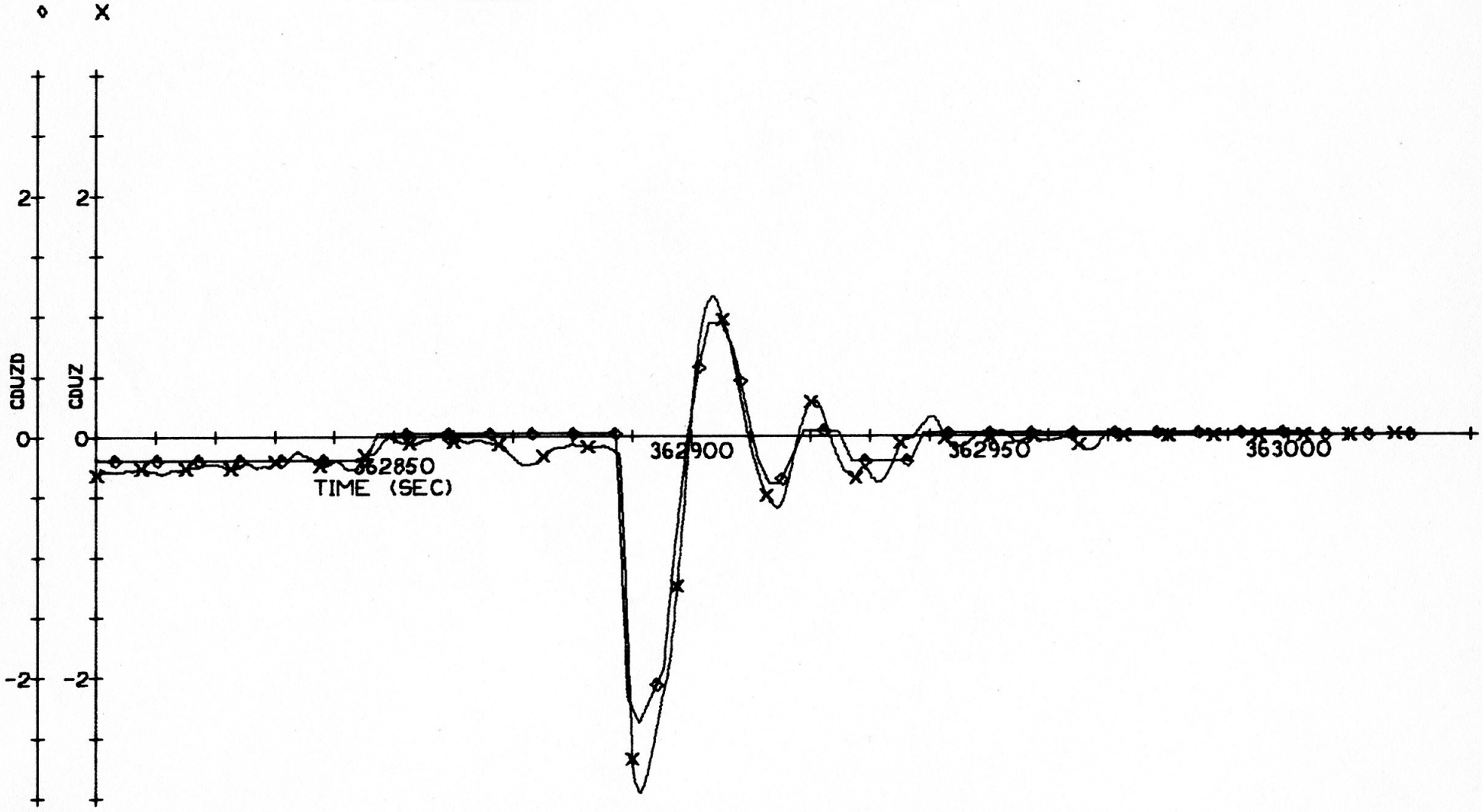
P64

P65

X'S MARK CDUZ
◇'S MARK CDUZD




1.5 F/S SPIKE, TGO -50, DB 0.3

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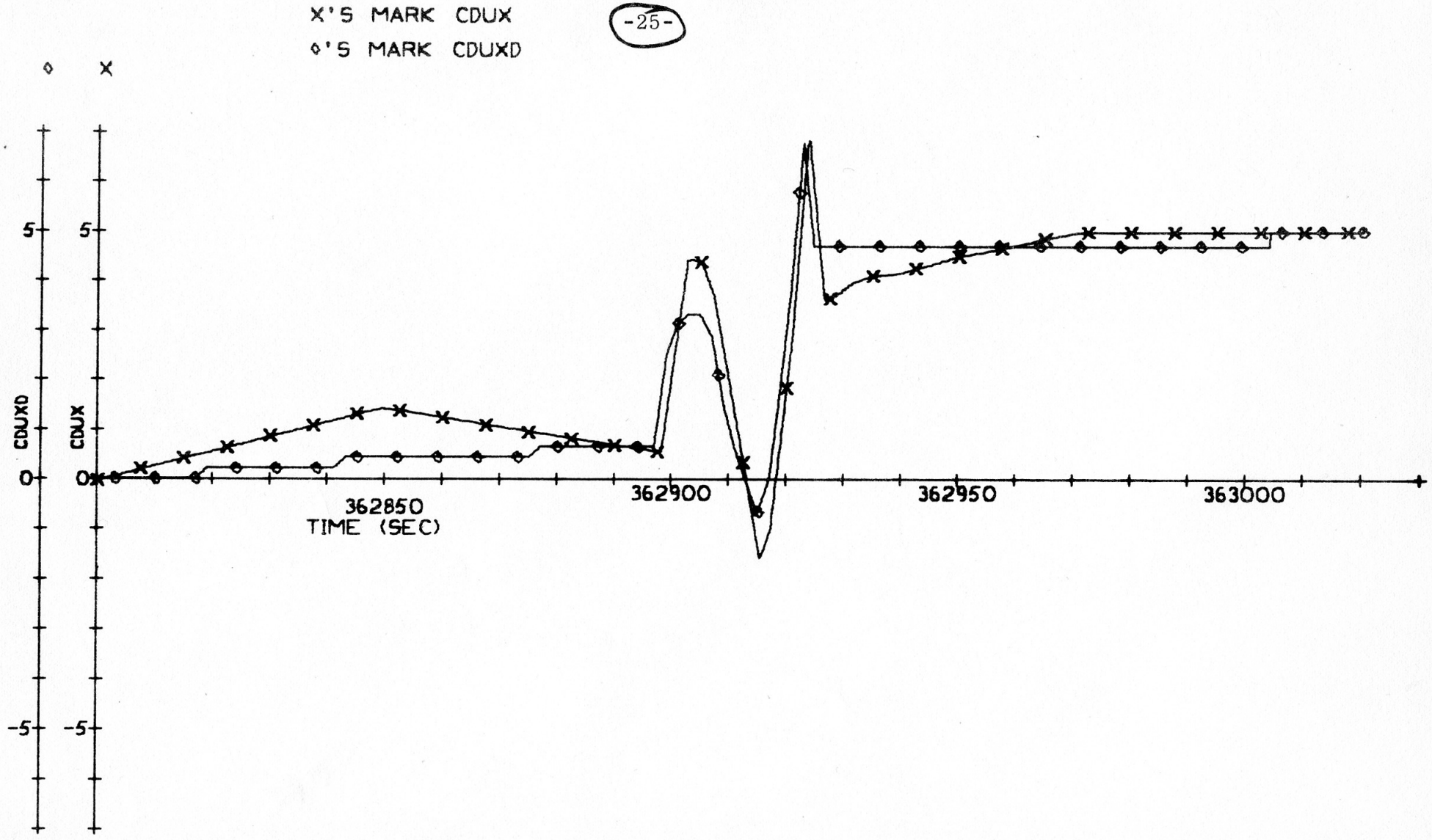


1.5 F/S SPIKE, TGO -40, DB 1.0

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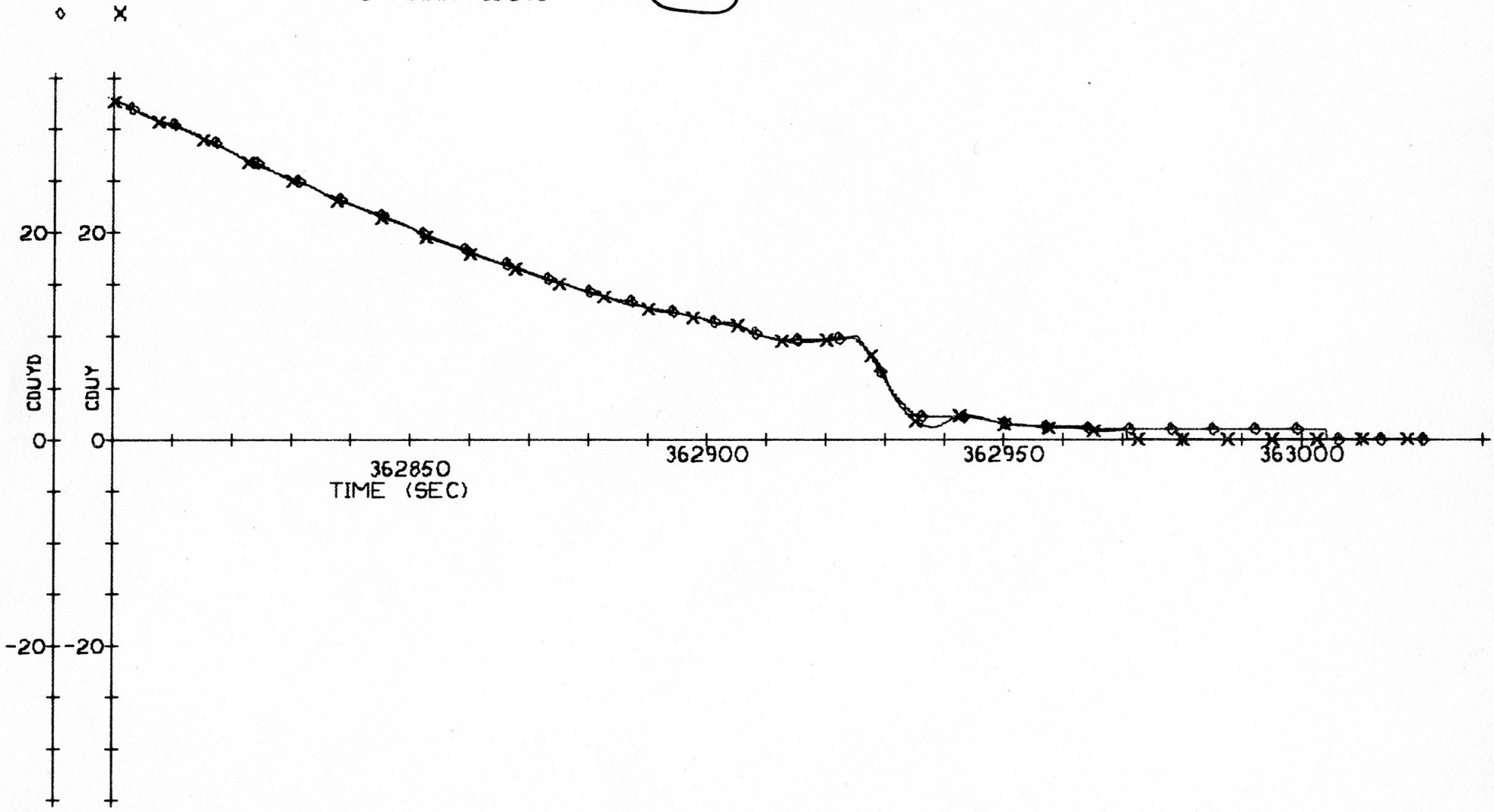
P64

P65

X'S MARK CDUY
◊'S MARK CDUYD




1.5 Γ/S SPIKE, TGD 40, DB 1.0

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P65

X'S MARK CDUZ

◊'S MARK CDU2D

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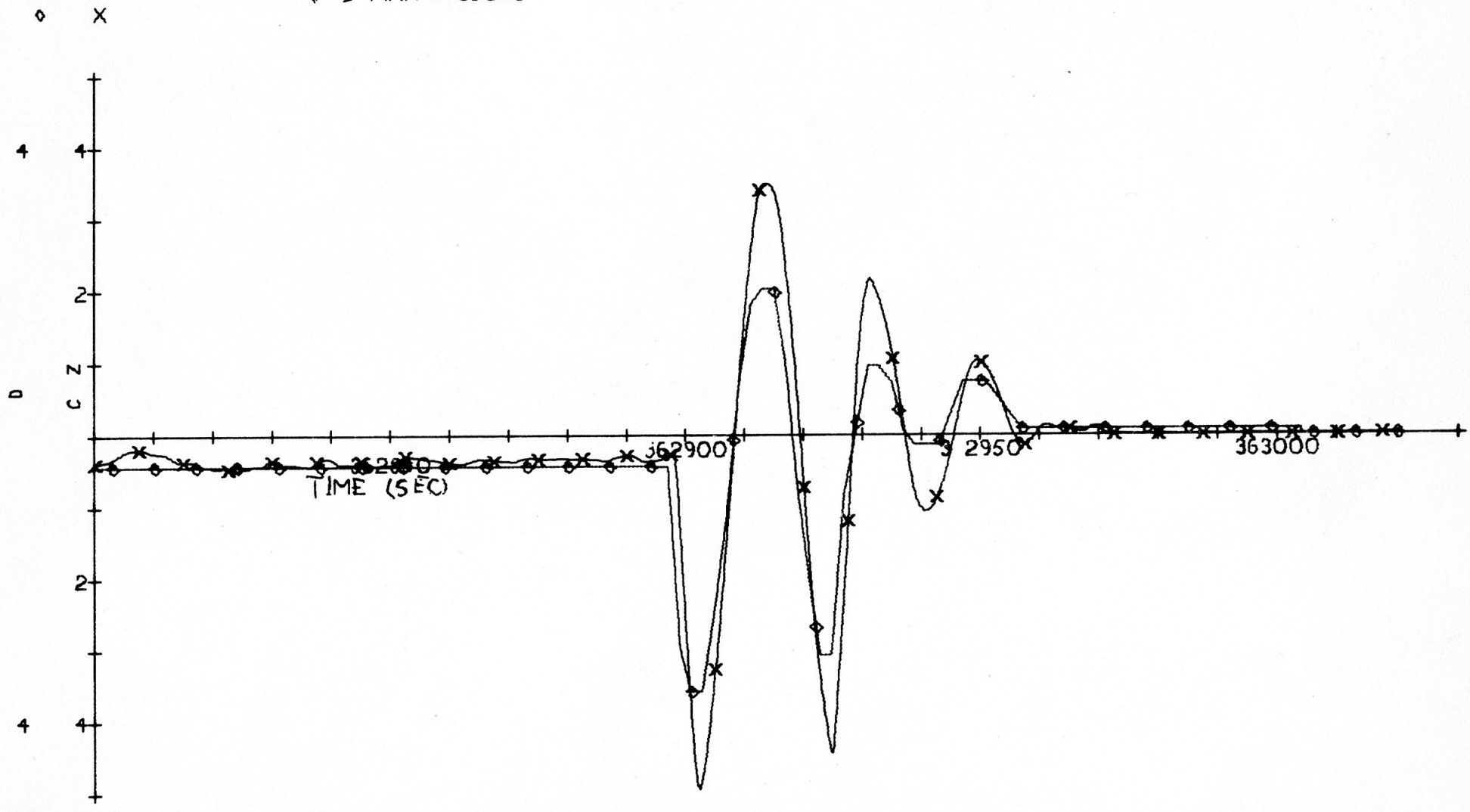


1.5 F/S SPIKE, TGO 40, D .0

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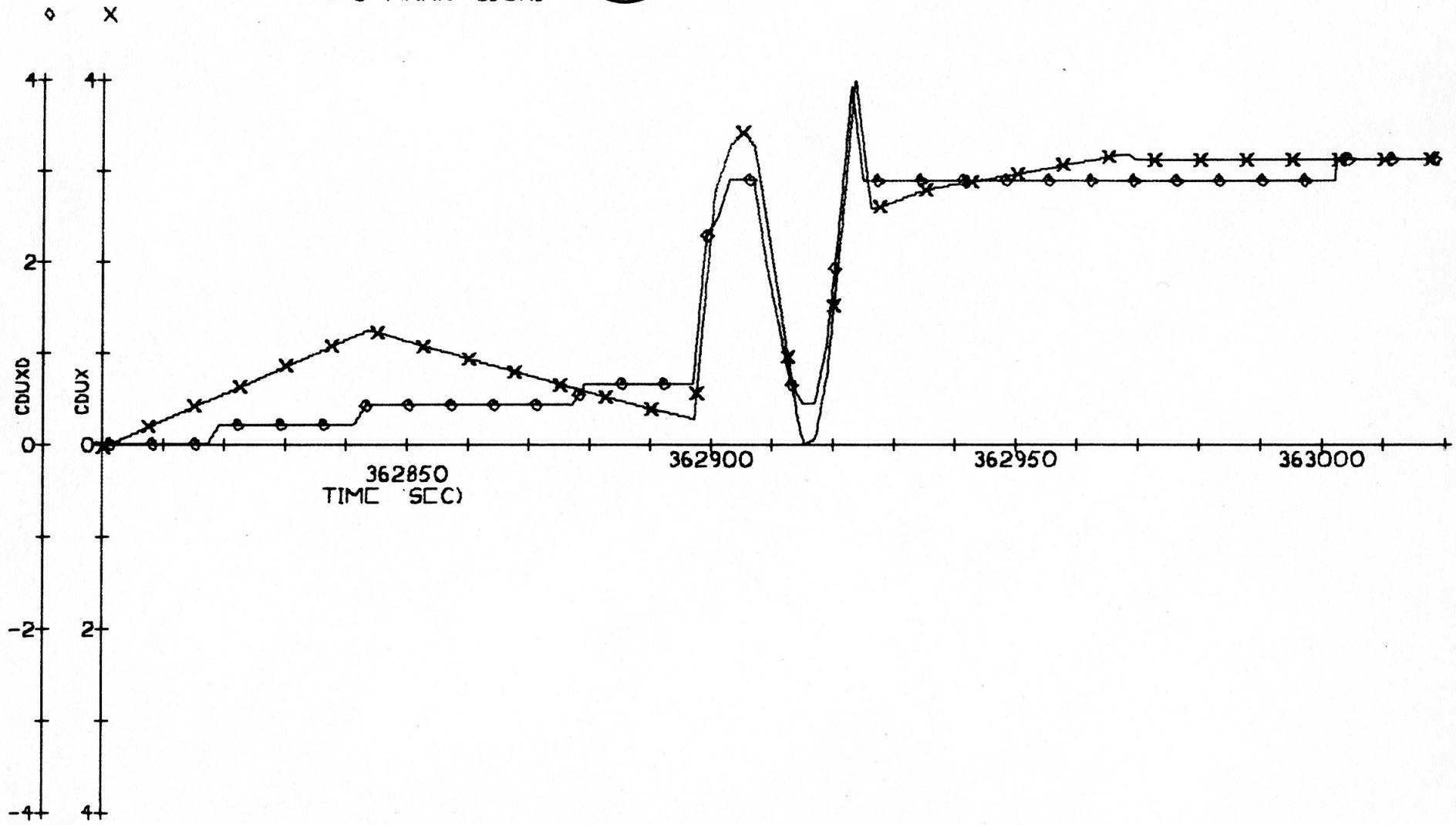
P65

X'S MARK CDUX
◇'S MARK CDUXD




1.5 Γ/S SPIKE, TGO -40, DB 0.3

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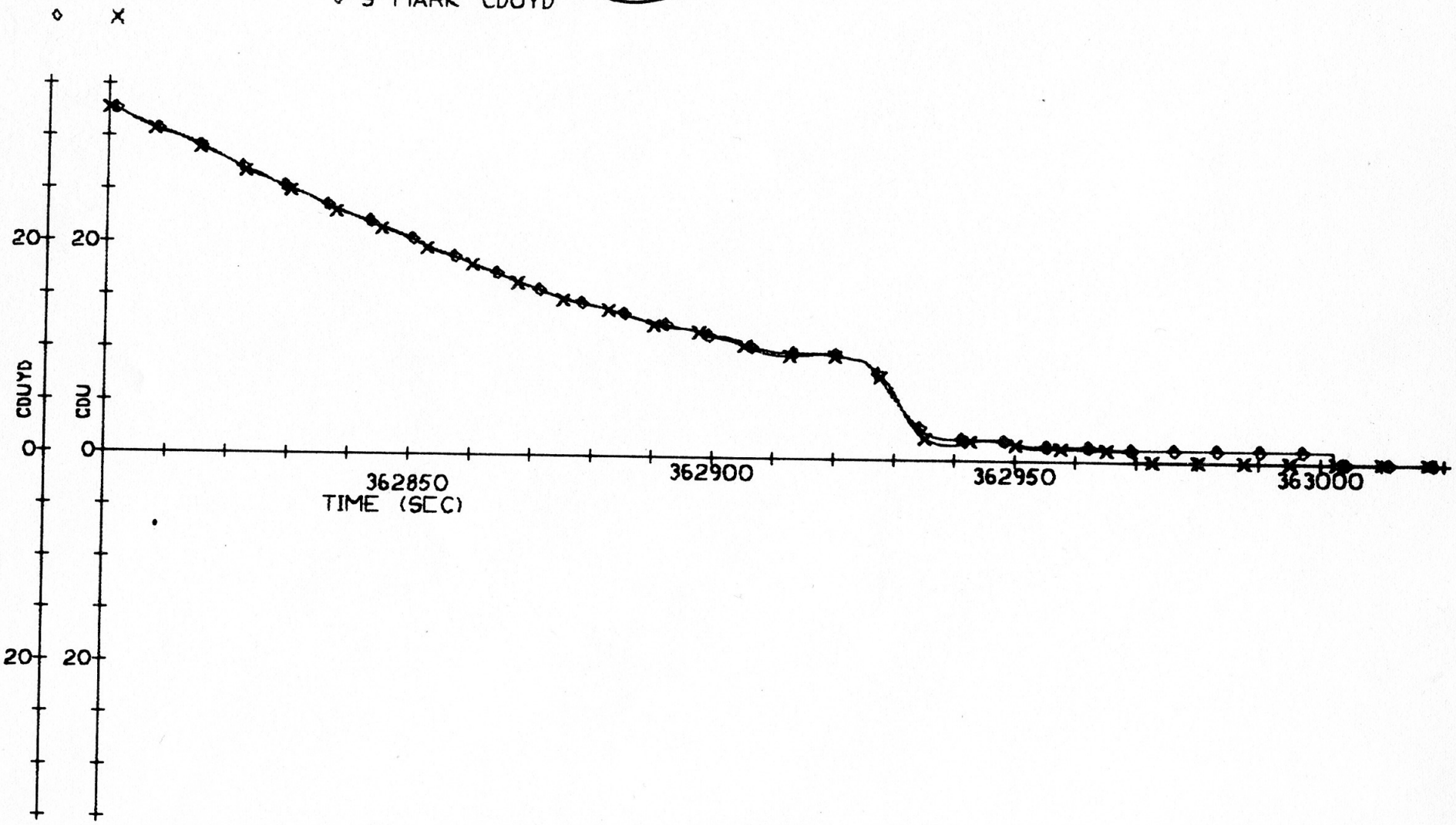
P64

P65

X'S MARK CDUY
◇'S MARK CDUYD




1.5 Γ/S SPIKE, TGO -40, DB 0.3

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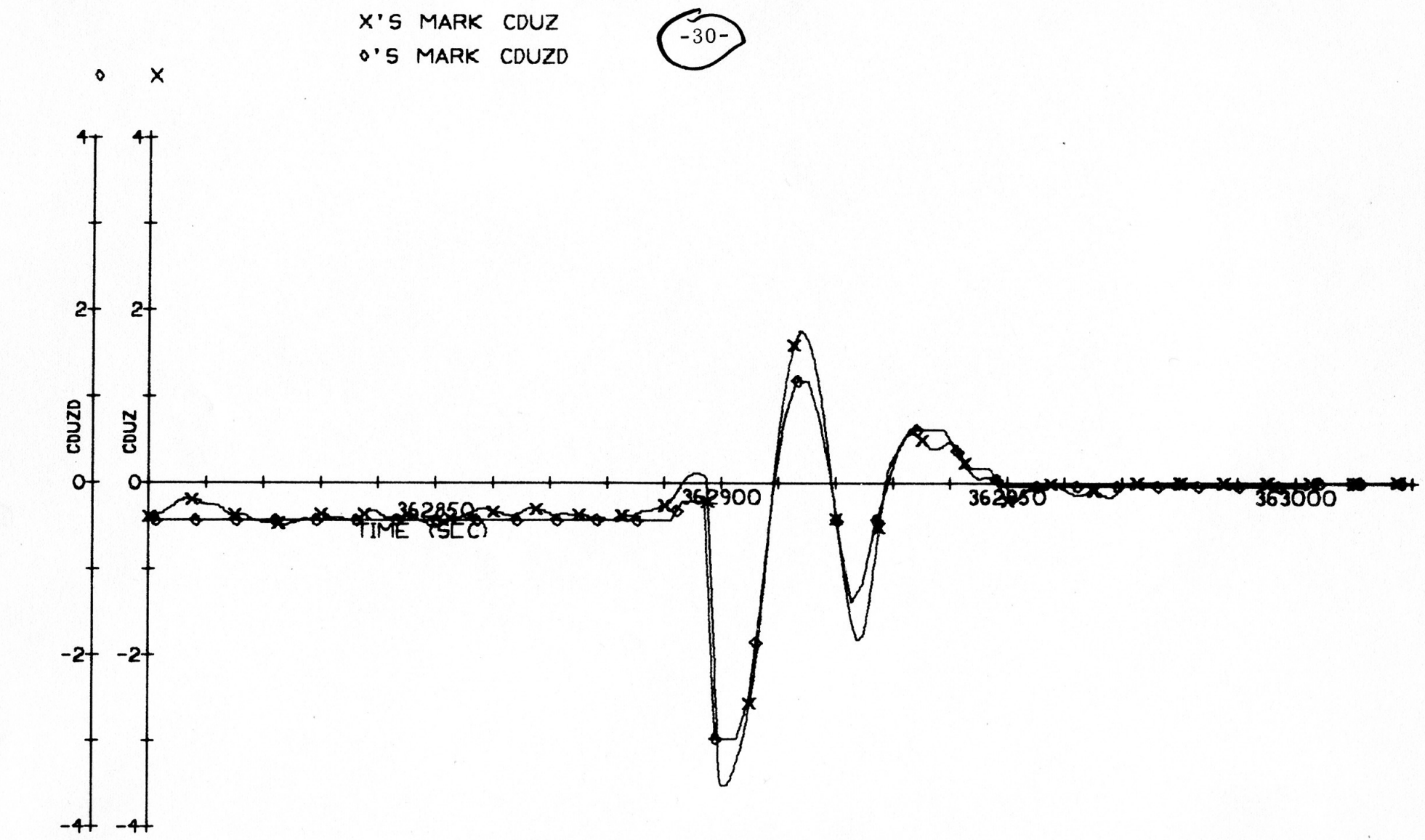
↑ D64

↑ 65




1.5 F/S SPIKE, TGO -40, DB 0.3

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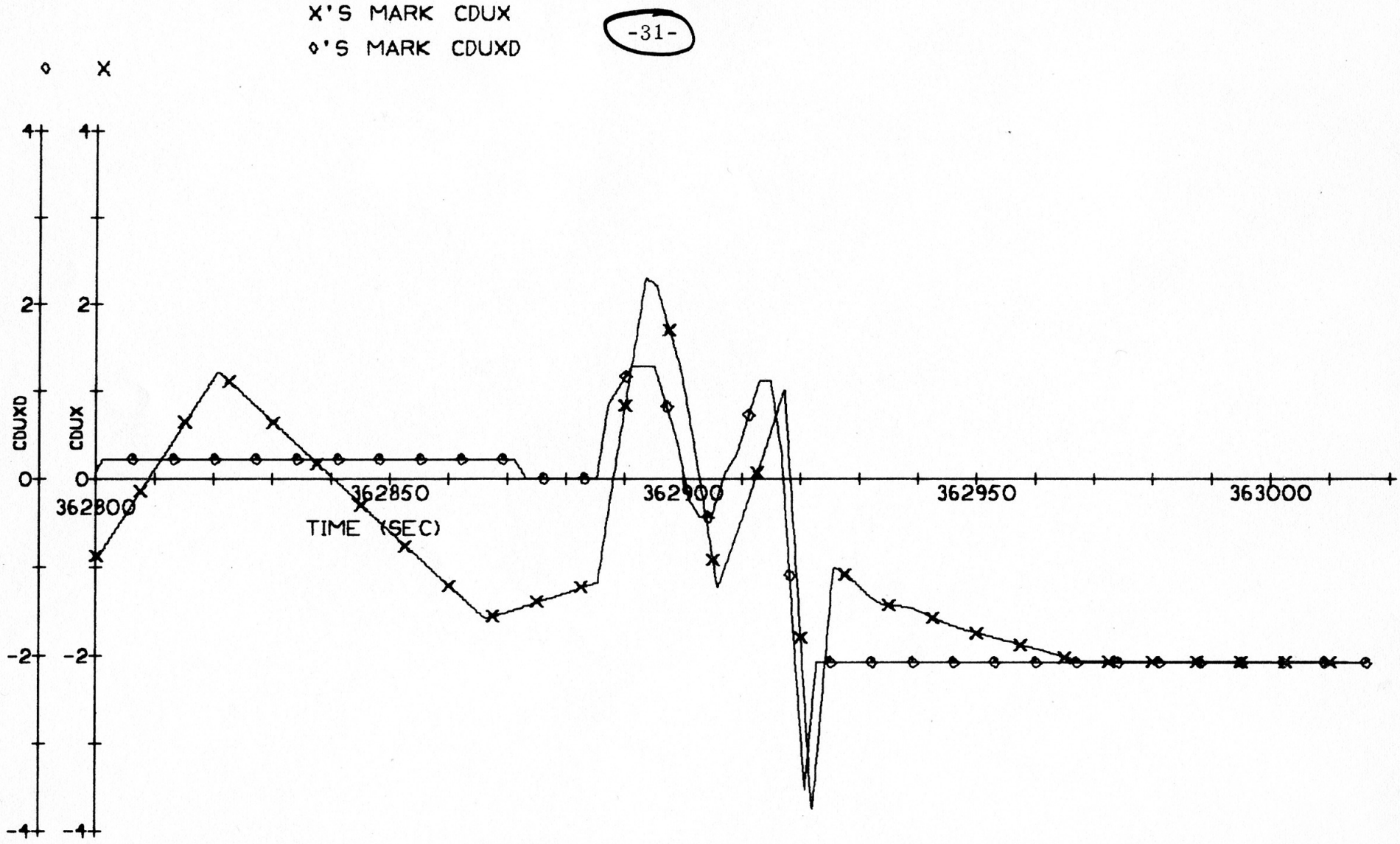
P64

P65



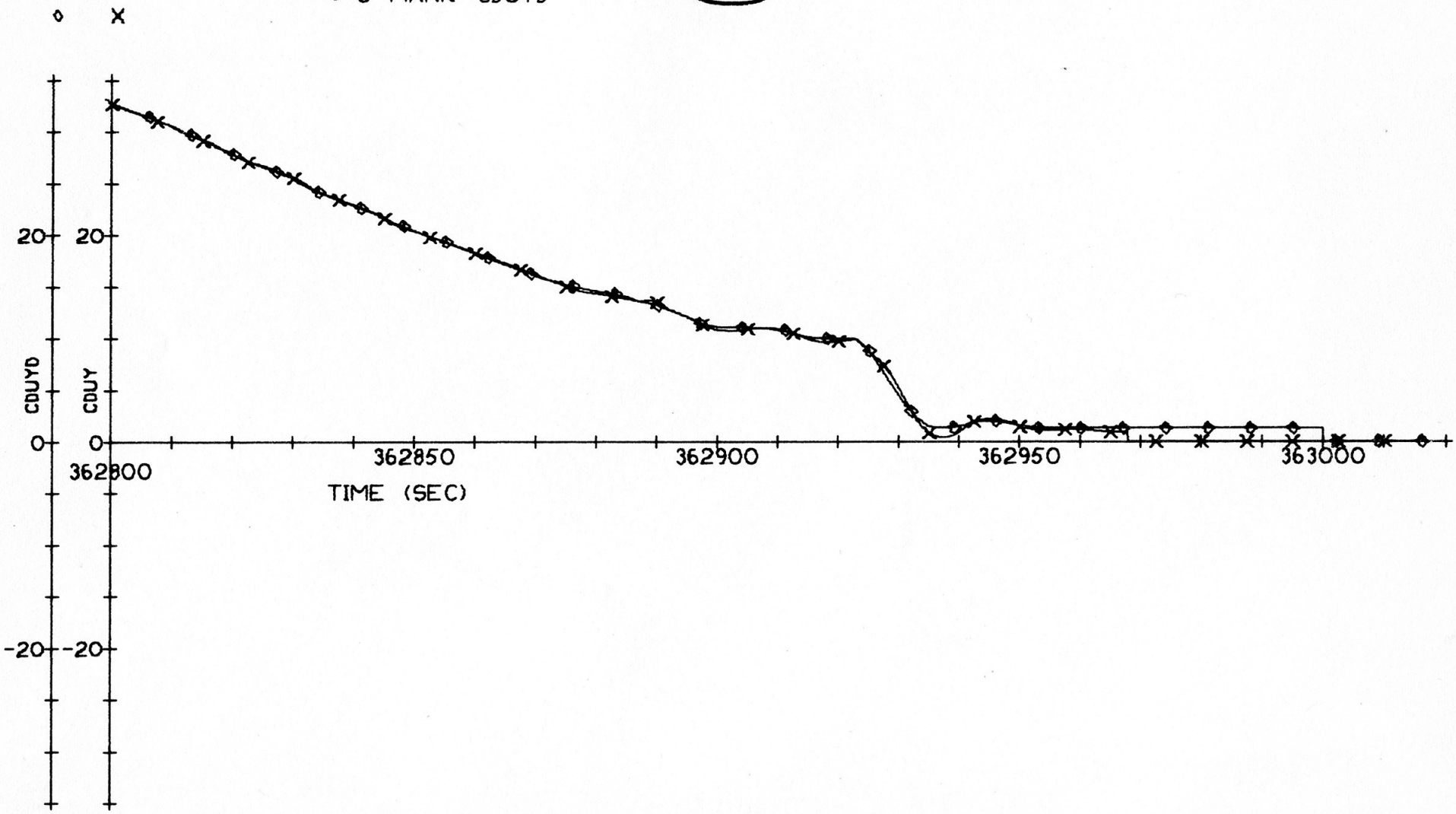

SPIKE, TGO -50, DB 1.0, LEAD 3.0

BO83984

P64

P65

X'S MARK CDUY
◊'S MARK CDUYD



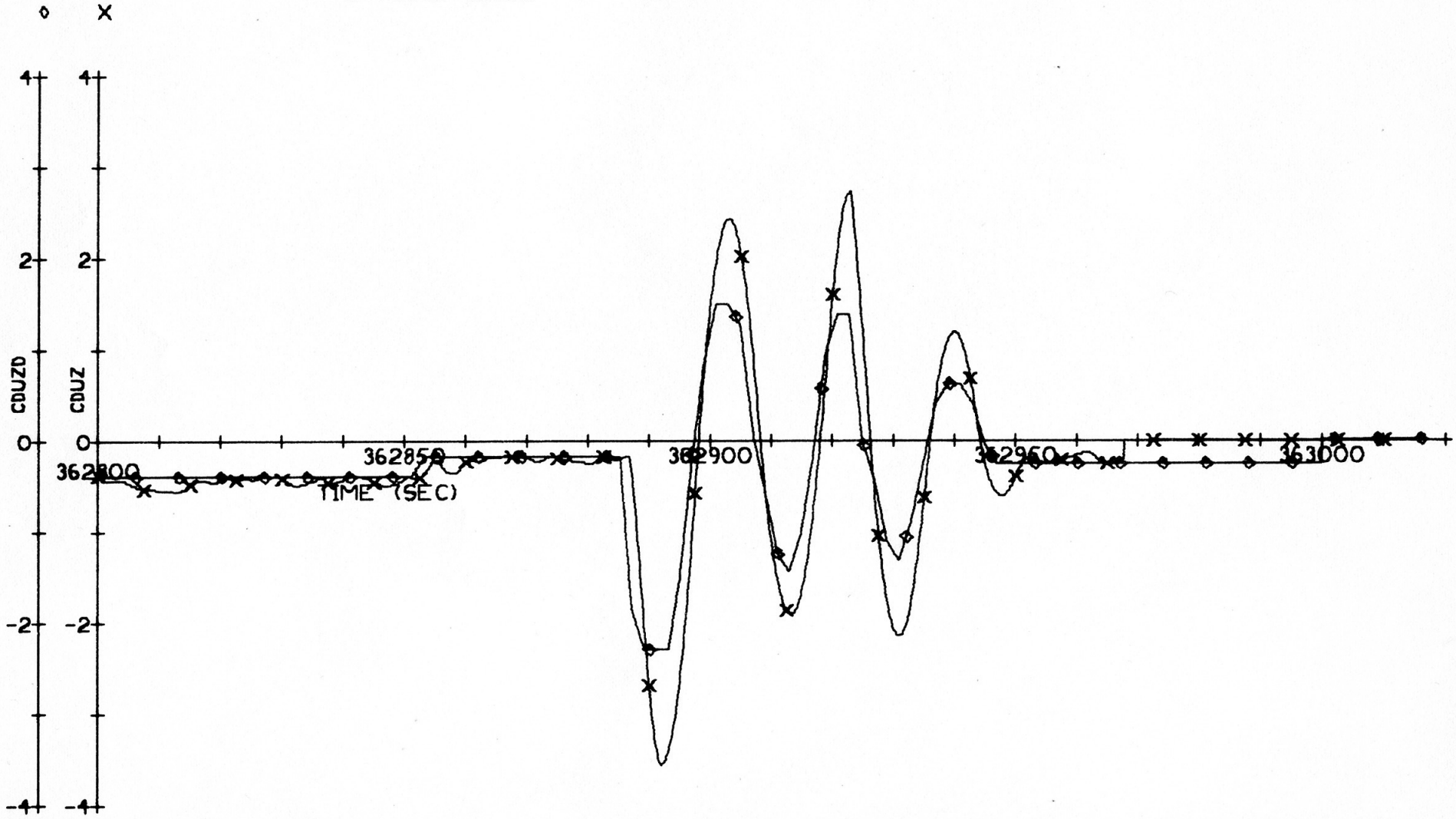

SPIKE, TGO -50, DB 1.0, LEAD 3.0

B083984

P64

P65

X'S MARK CDUZ
◇'S MARK CDUZD



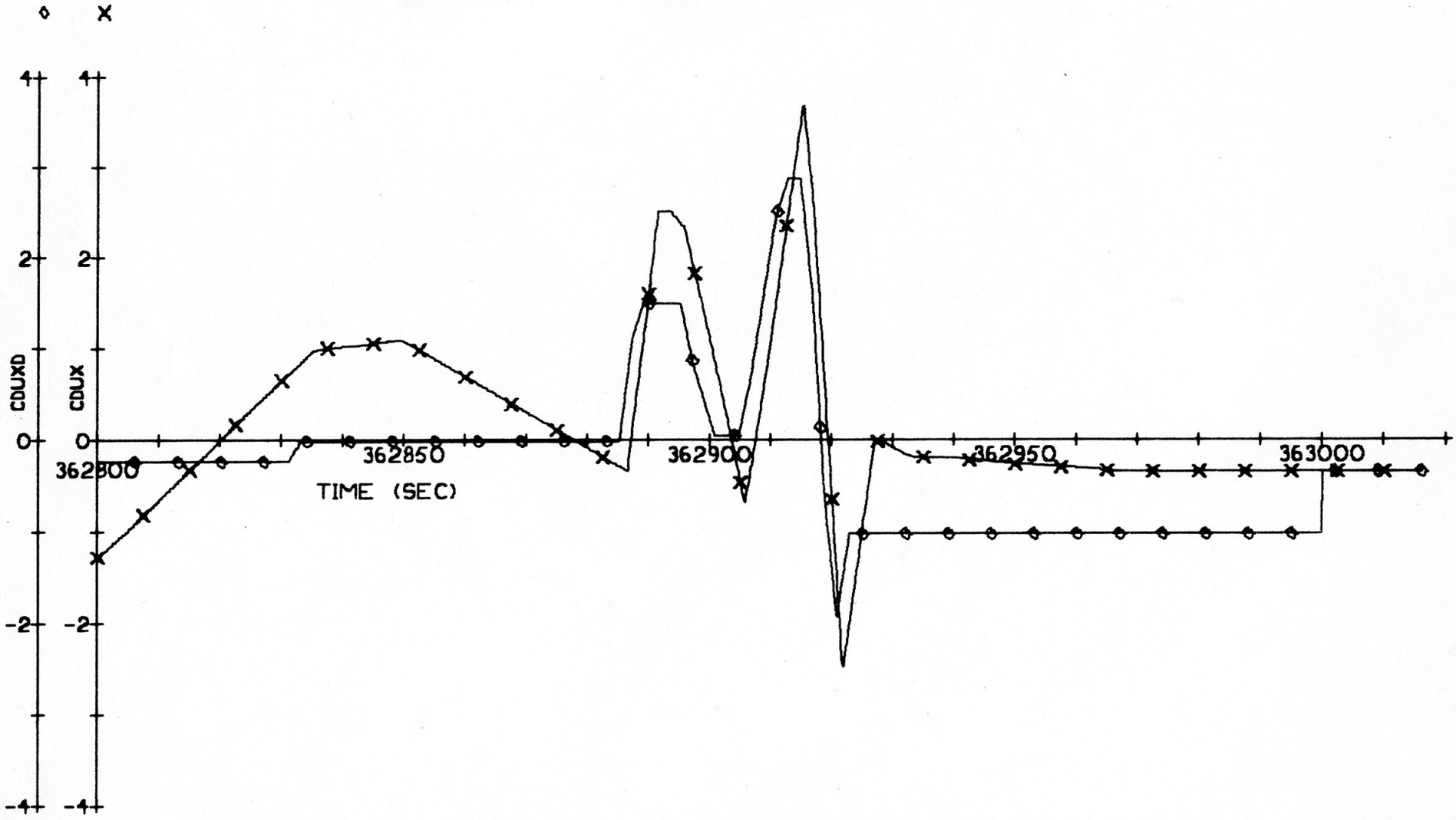

SPIKE, TGO -50.DB 1.0,LEAD 3.0

B083984

P64

P65

X'S MARK CDUX
◇'S MARK CDUXD

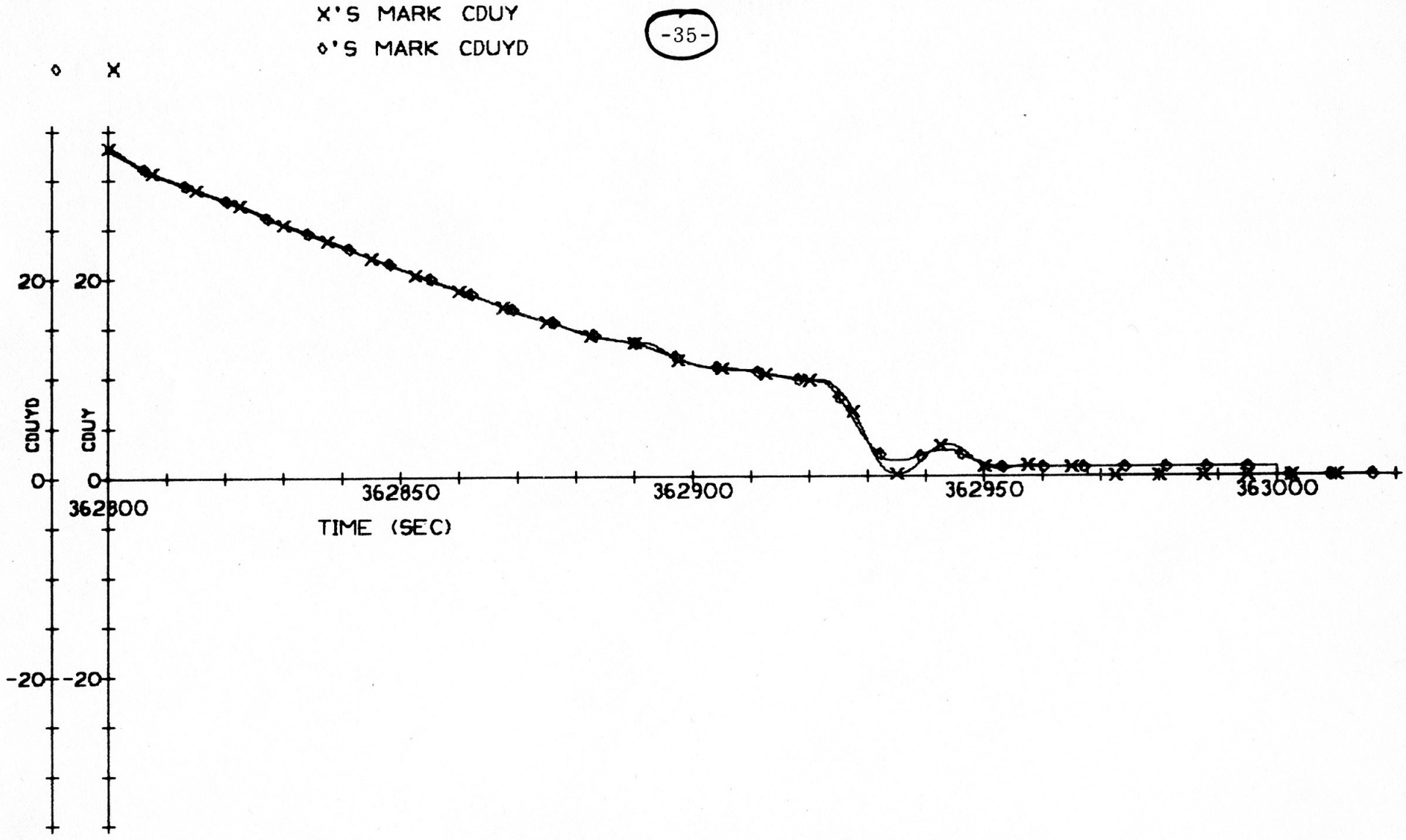



SPIKE, TGO -50,DB 1.0,LEAD 3.5

BO83985

P64

P65




SPIKE, TGO -50, DB 1.0, LEAD 3.5

B083985

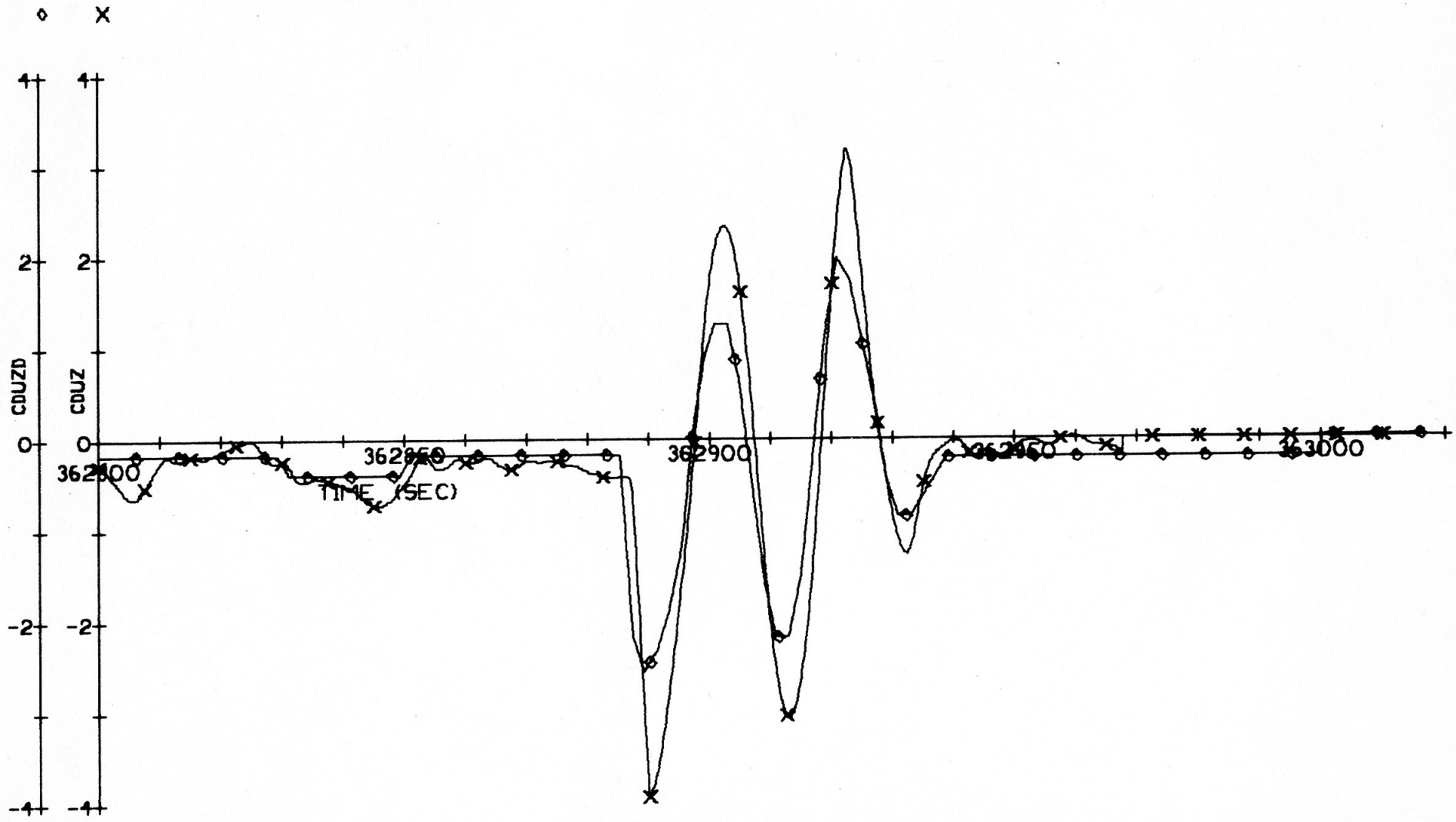
P64

P65

X'S MARK CDUZ

◇'S MARK CDUZD






SPIKE, TGO -50, DB 1.0, LEAD 3.5

B083985

P64

P65